CANADIAN
JOURNAL OF RESEARCH

VOLUME 17 DECEMBER, 1939 NUMBER 12

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NATIONAL RESEARCH COUNCIL
OTTAWA, CANADA

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	Annual	*Single Copy*
A and B	$ 2.50	$ 0.50
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The Canadian Journal of Research is published by the National Research Council of Canada under authority of the Chairman of the Committee of the Privy Council on Scientific and Industrial Research. All correspondence should be addressed:

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Canadian Journal of Research

Issued by THE NATIONAL RESEARCH COUNCIL OF CANADA

VOL. 17, SEC. C. DECEMBER, 1939 NUMBER 12

A DESCRIPTIVE LIST OF NATURAL AND ARTIFICIAL INTERSPECIFIC HYBRIDS IN NORTH AMERICAN FOREST-TREE GENERA[1]

BY L. P. V. JOHNSON[2]

Abstract

Over 400 hybrids involving 28 North American genera of forest trees are described in tabular form with the object, primarily, of providing useful information for the forest-tree breeder. The genera involved are: *Abies, Acer, Aesculus, Alnus, Arbutus, Betula, Carya, Castanea, Catalpa, Cornus, Crataegus, Cupressus, Gleditsia, Ilex, Juglans, Larix, Magnolia, Picea, Pinus, Platanus, Populus, Quercus, Robinia, Salix, Taxus, Tilia, Tsuga,* and *Ulmus.*

Introduction

For many years botanists have been describing natural hybrids, or to a lesser extent producing artificial hybrids, in forest-tree genera. This has led to the amassing of an extensive literature which, until recently, has been largely of academic or of secondary practical interest. With the recent advent of a number of forest-tree breeding projects, however, these data have been automatically greatly increased in their scientific and practical importance. This fact is believed to warrant the present attempt to review some of the more readily available literature on forest-tree hybrids, and to summarize it primarily with the view of providing useful information to the forest-tree breeder.

Scope of the Work

Upon undertaking the work it soon became apparent that, under the circumstances of limited time and facilities, it would be necessary to restrict its scope. As a result the present paper includes only those genera of forest trees that are represented in North America by indigenous species of considerable economic importance. The available literature, which it is believed covered the subject fairly well, was examined for data on hybridization in genera meeting these requirements. It was found that some 405 hybrids were reported in 28 of these genera, as follows:

ABIES Link. Fir	3 hybrids	ARBUTUS L. Madrona	1 hybrid
ACER L. Maple	9 hybrids	BETULA L. Birch	13 hybrids
AESCULUS L. Buckeye	11 hybrids	CARYA Nutt. Hickory	7 hybrids
ALNUS L. Alder	8 hybrids	CASTANEA Adans. Chestnut	15 hybrids

[1] *Manuscript received August 25, 1939.*
Contribution from the Division of Biology and Agriculture, National Research Laboratories, Ottawa. N.R.C. No. 864.

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CATALPA Scop. Catalpa	2 hybrids	PINUS Duham. Pine	20 hybrids
CORNUS L. Dogwood	5 hybrids	PLATANUS L. Plane-tree, Sycamore	1 hybrid
CRATAEGUS L. Hawthorn	5 hybrids	POPULUS L. Poplar	121 hybrids
CUPRESSUS L. Cypress	1 hybrid	QUERCUS L. Oak	77 hybrids
GLEDITSIA L. Locust	1 hybrid	ROBINIA L. Locust	4 hybrids
ILEX L. Holly	3 hybrids	SALIX L. Willow	42 hybrids
JUGLANS L. Walnut	16 hybrids	TAXUS L. Yew	2 hybrids
LARIX Adans. Larch	12 hybrids	TILIA L. Basswood, Linden	8 hybrids
MAGNOLIA L. Magnolia	5 hybrids	TSUGA Carr. Hemlock	1 hybrid
PICEA Dietr. Spruce	6 hybrids	ULMUS L. Elm	6 hybrids

There are a number of genera of considerable economic importance in which it has not been possible to find reports of hybrids. Among these genera are the following:

CARPINUS L. Hornbeam
CELTIS L. Hackberry
CHAMAECYPARIS Spach.
DIOSPYROS L. Persimmon
FAGUS L. Beech
FRAXINUS L. Ash
GYMNOCLADUS L.
JUNIPERUS L. Juniper
LIBOCEDRUS Endl. Resin Cedar
LIQUIDAMBAR L. Sweet Gum
LIRIODENDRON L. Yellow Poplar, Tulip-tree
LITHOCARPUS Blume Tan Bark Oak
MORUS L. Mulberry
NYSSA L. Sour Gum, Cotton Gum
OSTRYA Scop. Hop Hornbeam, Ironwood
PSEUDOTSUGA Carr. False Hemlock, Douglas Fir
SASSAFRAS Nees. Sassafras
SEQUOIA Endl. Redwood, Big Tree
SWIETENIA Jacq. Mahogany
TAXODIUM Rich. Bald Cypress
THUJA L. Arbor-vitae, Cedar
UMBELLULARIA Nutt.

Nomenclature

Any attempt to collect and summarize data involving botanical names applied by many authors and over many years is certain to be attended by considerable confusion arising from the inconsistencies of botanical nomenclature. It is not within the author's field to bring order and completeness out of the disorder and incompleteness that exist in the literature covering the material dealt with. For example, when a paper under review did not give authorities for the botanical names of parental material, no attempt was made to establish the exact identity of the material—the names of parents are given in the list without the addition of presumed authorities. The Latin endings of certain specific names have been changed to give conformity with accepted usage.

To give a degree of consistency to the present paper, the International Rules are followed wherever possible. For example, the sign × has been prefixed to all Latin names of hybrids, and the first letters of specific names are capitalized in cases where derivation is from the name of a person or of a genus.

Descriptive List of Forest-tree Hybrids

The summarization of collected data in forest-tree hybrids has been concerned primarily with giving, under selected headings, a highly condensed description which might prove useful to geneticists and plant breeders. When available, information on parental species has been included with the view of providing useful supplementary data. The descriptions are for the most part straightforward, but in some cases they may present difficulties. A short explanatory note on each heading follows:

No. The numbers under this heading are simply convenient numerical designations, which permit reference to any cross by number, and enable the reader to see at a glance the total number of crosses described for each genus.

Species involved. The practice of naming the female parent first is followed in general. Obviously, the rule cannot be applied very strictly in the case of natural hybrids of somewhat doubtful origin.

Nature of cross. The letters *N*, *A*, and *R* denote natural, artificial, and reciprocal crosses, respectively.

Chromosome nos. (n) involved. Under this heading are given the *n* (or reduced) chromosome numbers of the parental species involved. The sign × is placed between the numbers to correspond to its position under the heading *Species involved.* When two different numbers were reported in the literature one is given in parentheses—without, however, implying which number might be favoured by the author.

Name of hybrid. The sign × has been prefixed to all Latin names.

Notes on hybrid. Self-explanatory. In some cases space under this heading has been used for the extension of descriptions from other headings.

Country or region. Abbreviations are those in standard use.

Author and date of report or of origin. The author given may be the original reporter of the cross, the most important contributor to knowledge on the cross, or merely the author of the paper which chanced to be used as the main source in the present work. The reference number in parentheses refers to the main source in the present work. The date given before the semicolon refers to date of origin, the date after the author's name refers to the date of the report. The abbreviations *a.* and *b.* applied to date of origin denote *after* and *before*, respectively.

Other references. Here are listed by reference number the various papers which, in addition to the main source referred to in the preceding heading, have been used in compiling the information given for the cross in question.

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	ABIES LINK. FIR			
1	*A. Lowiana* Murr. × *A. grandis* Lindl.	A		
2	*A. cephalonica* Loud. × *A. pinsapo* Boiss.	R	12 ×	× *A. Vilmorinii* Mast.
3	*A. pinsapo* Boiss. × *A. Nordmanniana* Spach.	N, R	× 12	× *A. insignis* Carr.
	ACER L. MAPLE			
1	*A. pseudoplatanus* L. × *A. monspessulanum* L.		26 ×	× *A. coriaceum* Tausch
2	*A. platanoides* × *A. laetum*		13 ×	× *A. Dieckii* Pax.
3	*A. platanoides* L. × *A. Lobelii* Ten.	N	13 (11) ×	× *A. Dieckii* Pax.
4	*A. campestre* L. × *A. monspessulanum* L.	N		× *A. Bornmuelleri* Borb.
5	*A. campestre* L. × *A. Lobelii* Ten.			× *A. zoeschense* Pax.
6	*A. opalus* Mill. × *A. monspessulanum* L.			× *A. Peronai* Schwer.
7	*A. opalus obtusatum* Henry × *A. monspessulanum* L.	N		× *A. velutinum* Schwer.
8	*A. tataricum* L. × *A. monspessulanum* L.	N		× *A. pusillum* Schwer.
9	*A. tataricum* L. × *A. pennsylvanicum* L.	N		× *A. Boscii* Spach.
	AESCULUS L. BUCKEYE			
1	*A. Hippocastanum* L. × *A. Pavia* L.	N	20 (19) × 20	× *A. rubicunda* Lodd. × *A. carnea* Willd.
2	*A. glabra* Willd. × *A. hybrida* DC.		20 ×	× *A. arnoldiana* Sarg.
3	*A. discolor mollis* Sarg. × *A. neglecta georgiana* Sarg.		20 × 20	× *A. mutabilis* (Spach.) Scheele
4	*A. discolor mollis* Sarg. × *A. neglecta* Lindl.		20 ×	× *A. mutabilis induta* Sarg.
5	*A discolor mollis* Sarg. × *A. glabra leucodermis* Sarg.	N	20 × 20	× *A. Bushii* Schn.
6	*A. neglecta* Lindl. × *A. Pavia* L.	N	× 20	× *A. Dupontii* Sarg.
7	*A. glabra* Willd. × *A. Pavia* L.	N	20 × 20	× *A. mississippiensis* Sarg.
8	*A. octandra* Marsh. × *A. Pavia* L.		20 × 20	× *A. octandra hybrida* (DC.) *Sarg.*
9	*A. discolor mollis* Sarg. × *A. neglecta georgiana* Sarg.	N	20 × 20	× *A. Harbisonii* Sarg.
10	*A. glabra* Willd. × *A. octandra* Marsh.	N	20 ×	× *A. marylandica* Booth
11	*A. neglecta georgiana* Sarg. × *A. Pavia* L.	N	× 20	× *A. Dupontii Hessei* Sarg.
	ALNUS L. ALDER			
1	*A. cordata* Desf. × *A. subcordata* C.A. Mey.	N	14 (21) × 14 (21)	
2	*A. subcordata* C.A. Mey. × *A. incana* Moench.		14 (21) × 14	× *A. Koehneii* Callier
3	*A. cordata* Desf. × *A. glutinosa* Gaertn.		14 (21) × 14	× *A. elliptica* Requiem.
4	*A. glutinosa* Gaertn. × *A. incana* Moench.	N, A	14 × 14	× *A. hybrida* A. Br.
5	*A. japonica* Sieb. & Zucc. × *A. incana* Moench.	N	14 × 14	× *A. spectabilis* Callier
6	*A. subcordata* C.A. Mey. × *A. japonica* Sieb. & Zucc.	N	14 × 14	× *A. Spaethii* Callier
7	*A. rugosa* Spring. × *A. incana* Moench.	N	14 × 14	× *A. Aschersoniana* Callier
8	*A. rugosa* Spring. × *A. glutinosa* Gaertn.	N	14 × 14	× *A. silesiaca* Fiek.
	ARBUTUS L. MADRONA			
1	*A. Andrachne* L. × *A. Unedo* L.	N	13 ×	× *A. andrachnoides* Lk.
	BETULA L. BIRCH			
1	*B. pubescens* Ehrh. × *B. verrucosa* Ehrh.	N, A N, A	28 × 14 28 × 14	× *B. Jackii* Schn.
2	*B. pumila* Michx. × *B. lenta* L.			

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
intermediate; vigorous growth.	Denmark	1924; Larsen, 1937	(52)	51.	1
quantitative characters intermediate.	France	Flous, 1937	(23)	66, 71.	2
also × *A. Beissneriana* Mott., or *A. Ernesti* Rehd.	China, Eng., Fr.	1872; Rehder, 1927	(66)	71, 109.	3
also × *A. Duretti* Pax., *A. hybridum* Spach., *A. rotundilobum* Schwer.; cult. 1790.		Rehder, 1927	(66)	24, 27, 74, 82.	1
		Schreiner, 1937	(74)	24, 26, 18.	2
similar to *A. platanoides*.		Rehder, 1927	(66)	18, 26, 82.	3
	S.E. Europe	Rehder, 1927	(66)		4
cultivated 1880.		Rehder, 1927	(66)		5
cultivated 1905.	Italy, France	Rehder, 1927	(66)		6
cultivated 1894.		Rehder, 1927	(66)		7
cultivated 1870.		Rehder, 1927	(66)		8
		b. 1834; Rehder, 1927	(66)		9
fertile; habit, foliage like *A. Hip.*; flowers like *A. Pav.* $F_1n=40$	England	b. 1818; Crane, 1935	(17)	28, 43, 62, 66, 76, 84, 27.	1
	U.S.A., Mass.	1900; Rehder, 1927	(66)	27, 43, 74.	2
cultivated 1834.	U.S.A., Mass.	1900; Rehder, 1927	(66)	27, 43, 74.	3
also *A. mutabilis penduliflora* Sarg., cultivated 1834.	U.S.A., Mass.	1900; Rehder, 1927	(66)	27, 43, 74.	4
introduced U.S.A. 1901.	Ark., Miss., Mass.	Sargent, 1921	(67)	27, 43, 66, 74.	5
	U.S.A., Del.	a. 1820; Rehder, 1927	(66)	28, 74, 76.	6
intermediate; introduced U.S.A. 1913.	U.S.A., Miss.	Sargent, 1921	(67)	27, 28, 43, 66, 74. 76.	7
	Europe, U.S.A. (E)	Sargent, 1921	(67)	27, 28, 43, 66, 76.	8
introduced U.S.A. 1905; $F_1n=20$	U.S.A., Ga., Mass.	Sargent, 1921	(67)	27, 43, 66.	9
		Rehder, 1927	(66)	27, 43.	10
cultivated 1909.		Rehder, 1927	(66)	28, 76.	11
pronounced hybrid vigor.	Denmark	Larsen, 1937	(52)	27, 29, 46, 92, 93.	1
		Larsen, 1937	(52)	27, 29, 46, 66, 92, 93.	2
		Larsen, 1937	(52)	27, 29, 46, 66, 92, 93.	3
	Germany	Klotzsch, 1854	(52)	27, 29, 46, 66, 92, 93.	4
		b. 1908; Rehder, 1927	(66)	27, 93.	5
		b. 1908; Rehder, 1927	(66)	27, 93.	6
	Europe	Rehder, 1927	(66)	27, 29, 93, 98.	7
	Europe	Rehder, 1927	(66)	27, 29, 92, 93, 98.	8
intermediate.	Greece	1800; Rehder, 1927	(66)	27, 34.	1
fertile; intermediate; several forms.	N. Europe	Morgenthaler, 1915	(58)	27, 39, 52.	1
$F_1n=21$; tends to resemble *B. lenta* L.; cultivated 1895; shrub.	U.S.A. (N.E.)	Cousins, 1933	(16)	28, 66, 67, 97.	2

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	***BETULA* L. BIRCH (Continued)**			
3	*B. coerulea-grandis* Blanch. × *B. populifolia* Ait.	N	× 14	× *B. coerulea* Blanch.
4	*B. papyrifera* Marsh. × *B. pumila* var. *glandulifera* Regel.	N	35 × 28	× *B. Sandbergii* Britt.
5	*B. lutea* Michx. × *B. pumila* var. *glandulifera* Regel.	N	42 × 28	× *B. Purpusii* Schn.
6	*B. nana* L. × *B. verrucosa* Ehrh.	N	14 × 14	× *B. intermedia* Thomas
7	*B. alaskana* Sarg. × *B. glandulosa* Michx.	N		× *B. commixta* Sarg.
8	*B. populifolia* Ait. × *B. papyrifera* Marsh.	N	14 (?) × 35	
9	*B. pendula* Roth. × *B. papyrifera* Marsh.	N	14 × 35	× *B. Koehnei* Schneid.
10	*B. pendula* Roth. × *B. pubescens* Ehrh.	N	14 ×	× *B. aurata* Bechst.
11	*B. pumila* L. × *B. papyrifera* Marsh.	N	28 × 35	× *B. excelsa* Ait.
12	*B. nana* L. × *B. pubescens* Ehrh.	N	14 ×	× *B. intermedia* Thomas
13	*B. nana* L. × *B. pendula* Roth.	N	14 × 14	× *B. fennica* Doerfl.
	***CARYA* Nutt. (*HICORIA* Rafn.) HICKORY**			
1	*C. pecan* (Marsh.) Brit. × *C. cordiformis* (Wang.) Brit.	N	× 16	× *C. Brownii* (Sarg.) Ashe
2	*C. cordiformis* (Wang.) Brit. × *C. ovata* (Mill.) Brit.	N	16 × 16	× *C. Laneyi* (Sarg.) Sudw.
3	*C. pecan* (Marsh.) Brit. × *C. laciniosa* (Michx.) Sarg.	N	× 16	× *C. Nussbaumerii* (Sarg.) Sudw.
4	*C. alba* (L.) Brit. × *C. pecan* (Marsh.) Brit.	N	32 ×	× *C. Schneckii* (Sarg.) Sudw.
5	*C. laciniosa* Schn. × *H. ovata* K. Koch.	N	16 × 16	× *C. Dunbarii* Sarg.
6	*C. aquatica* Nutt. × *C. pecan* Engl. & Graebn.			× *C. texana* (Le Coute) C. DC.
7	*C. cordiformis* K. Koch. × *C. ovalis* Sarg.		16 × 32	× *C. Demareei* E. J. Palmer
	***CASTANEA* ADANS. CHESTNUT**			
1	*C. mollissima* × *C. dentata*	A, R	× 12	
2	*C. crenata* (forest types) × *C. dentata*	A	11 × 12	
3	*C. crenata* (forest types) × *C. mollissima*	A	11 ×	
4	*C. crenata* (forest types) × *C. Henryi*	A	11 X	
5	*C. mollissima* × *C. Henryi*	A		
6	*C. pumila* × *C. Seguinii*	A		
7	*C. mollissima* × *C. Seguinii*	A		
8	*C. crenata* × *C. Seguinii*	A	11 ×	
9	(*C. crenata* × *C. dentata*) × *C. mollissima*	A, R		
10	(*C. mollissima* × *C. pumila*) × *C. dentata*	A	× 12	
11	*C. dentata* Borkh. × *C. pumila* Mill.	N	12 ×	× *C. neglecta* Dode.
12	*C. pumila* Mill. × *C. sativa* Mill.		× 11 (12)	
13	*C. sativa* Mill. × *C. dentata* Borkh.		11 (12) × 12	
14	*C. crenata* Sieb. & Zucc. × *C. dentata* Borkh.	A	11 × 12	
15	*C. crenata* Sieb. & Zucc. × *C. pumila* Mill.	N, A		

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
introduced 1905; $F_1n=14$.	N. Am.; N.S. to Vt.	Rehder, 1927	(66)	28, 97.	3
$F_1n=31$–32.	U.S.A., Minn.	Sargent, 1921	(67)	28, 29, 74, 97, 99.	4
$F_1n=45$; cultivated 1900; meiosis very abnormal.	U.S.A., Mich., Minn.	Sargent, 1921	(67)	28, 29, 66, 74, 97, 99.	5
		Schreiner, 1937	(74)	27, 28, 29, 39, 66, 94, 99.	6
	Canada, Yukon T.	Sargent, 1921	(67)		7
	U.S.A., Mass.	Rehder, 1927	(66)	28, 97.	8
meiosis *B. pen.* very abnormal; parents uncertain; cultivated 1905.		Rehder, 1927	(66)	28, 97.	9
meiosis *B. pen.* very abnormal.	Europe	Rehder, 1927	(66)	28, 97.	10
hybridity uncertain; also *B. Borggreveana* Zabel; cultivated 1789.		Rehder, 1927	(66)	28, 29, 97, 99.	11
cultivated 1895.	Europe	Rehder, 1927	(66)	27, 28, 93, 94.	12
	Europe	Rehder, 1927	(66)	27, 28, 93, 94, 97.	13
similar to *C. pecan;* var. *variens* Sarg., cult.	U.S.A., Ark., Ohio	Sargent, 1921	(67)	29, 66, 74, 100.	1
$F_1n=16$, meiosis abnormal; var. *chateaugayensis* Sarg.; cultivated.	U.S.A., N.Y.; Can., Que., Ont.	Sargent, 1921	(67)	29, 66, 74, 100.	2
very vigorous; branch, fruit like *C. pecan;* leaves like *C. laciniosa*; cultivated.	U.S.A., Ill., Ind., Ia., Mo.	Sargent, 1921	(67)	29, 66, 74, 100, 106.	3
parentage not certain; cultivated.	U.S.A., Ill., Ia.	Sargent, 1921	(67)	29, 66, 74, 100.	4
intermediate, but parentage not certain.	U.S.A., Golah, N.Y.	Sargent, 1921	(67)	29, 100.	5
range of variability in fruit characters between *C. aquatica* and *C. pecan*.	U.S.A. (S.W.)	Palmer, 1937	(108)		6
intermediate in foliage, fruit and winter buds.	U.S.A., Ark.	Palmer, 1937	(108)	29, 100.	7
marked hybrid vigor; 272 seedlings.	U.S.A., N.Y., etc.	Schreiner, 1937	(73)	29, 46.	1
backcrosses; F_2 produced; timber types; blight resistant.	U.S.A., N.Y., etc.	Schreiner, 1937	(73)	27, 29, 46, 93.	2
hybrid vigor, 44 seedlings.	U.S.A.	Schreiner, 1937	(73)	27, 93.	3
hybrid vigor, 3 seedlings.	U.S.A.	Schreiner, 1937	(73)	27, 93.	4
hybrid vigor, 16 seedlings.	U.S.A.	Schreiner, 1937	(73)		5
everblooming of *C. Seguinii* dominant; 21 seedlings.	U.S.A.	Schreiner, 1937	(73)		6
everblooming of *C. Seguinii* dominant; 19 seedlings.	U.S.A.	Schreiner, 1937	(73)		7
everblooming of *C. Seguinii* dominant; 24 seedlings.	U.S.A.	Schreiner, 1937	(73)	27, 93	8
	U.S.A., N.Y.	Schreiner, 1937	(73)		9
	U.S.A., N.Y.	Schreiner, 1937	(73)	29, 46.	10
intermediate.	Macon Co., N.C., U.S.A.	Sargent, 1921	(67)	29, 46, 66.	11
fertile.	U.S.A., N.J.	1903; Van Fleet; Fairchild, 1918.	(21)	27, 29, 46, 66, 93.	12
		Rehder, 1927	(66)	27, 29, 46, 93.	13
variable dominance; F_2 produced; remarkable vigor.	U.S.A., Ill.	1908; Detlefsen & Ruth, 1922.	(19)	27, 29, 46, 66, 93.	14
blight resistance (from *C. crenata*) dominant.		b. 1911; Rehder, 1927	(66)	6, 27, 93.	15

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	CATALPA SCOP. CATALPA			
1	*C. bignonioides* Walt. × *C. ovata* Don			× *C. hybrida* Spaeth
2	*C. Kaempferi* (= *C. ovata*) × *C. bignonioides*			
	CORNUS L. DOGWOOD			
1	*C. rugosa* Lam. × *C. stolonifera* Michx.	N		× *C. Slavinii* Rehd.
2	*C. obliqua* Raf. × *C. racemosa* Lam.	N		× *C. arnoldiana* Rehd.
3	*C. macrophylla* Wall. × *C. Amomum* Mill.	N		× *C. Horseyi* Rehd.
4	*C. macrophylla* Wall. × *C. asperifolia* Michx.	N		× *C. Dunbarii* Rehd.
5	*C. paucinervis* Hance × *C. Amomum* Mill.	N		× *C. dubia* Rehd.
	CRATAEGUS L. HAWTHORN			
1	*C. oxyacantha* L. × C. *monogyna* Jacq.	N	16 × 16	× *C. media* Bechst.
2	*C. crus-galli* L. × *C. pubescens* Steud.	N	24 ×	× *C. Lavallei* Herincq
3	*C. sanguinea* Pall. × *C. nigra* Kit.	N	16 (?) ×	× *C. Lambertiana* Lge.
4	*C. pentagyna* Waldst. & Kit. × *C. crus-galli* L.	N	× 24	× *C. hiemalis* Lge.
5	*C. tanacetifolia* Pers. × *C. punctata*.	N		× *C. Dippeliana* Lge.
	CUPRESSUS L. CYPRESS			
1	*C. macrocarpa* Hartw. × *C. nootkatensis* Don	N, R		× *C. Leylandii* J. & D.
	GLEDITSIA L. LOCUST			
1	*G. triacanthos* L. × *G. aquatica* Marsh.			× *G. texana* Sarg.
	ILEX L. HOLLY			
1	*I. Aquifolium* L. × *I. perado*			× *I. altaclarensis* Dallim.
2	*I. Aquifolium* L. × *I. latifolia* Thunb.			× *I. Koehneana* Loes.
3	*I. Aquifolium* L. × *I. dipyrena* Wall.			× *I. Beanii* Rehd.
	JUGLANS L. WALNUT			
1	*J. regia* L. × *J. nigra* L.	N, R	16 × 16	× *J. intermedia* Carr.
2	*J. regia* L. × *J. cinerea* L.	N	16 × 16	× *J. quadrangulata* Rehd.
3	*J. nigra* L. × *J. Hindsii* Rehd.	A	16 × 17	Royal Black Walnut
4	*J. Hindsii* Rehd. × *J. regia* L.	A	17 × 16	Paradox Walnut
5	*J. Sieboldiana* Max. × *J. cinerea* L.	N, A	16 × 16	× *J. Bixbyi* Rehd.
6	*J. Sieboldiana* Max. × *J. regia* L.		16 × 16	× *J. notha* Rehd.
7	*J. Hindsii* × Royal hybrid	A, R	17 ×	
8	Royal hybrid × *J. mandshurica*	A	× 16	
9	Royal hybrid × *J. regia*	A	× 16	
10	*J. mandshurica* × *J. regia*	A	16 × 16	
11	*J. mandshurica* × *J. Sieboldiana*	A	16 × 16?	
12	*J. mandshurica* × *J. cordiformis*	A	16 × 16?	
13	*J. mandshurica* × *J. nigra*	A	16 × 16	
14	*J. mandshurica* × *J. cinerea*	A, R	16 × 16	
15	*J. nigra* × *J. cinerea*		16 × 16	
16	*J. Sieboldiana* × *J. nigra*		16(?) × 16	

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
intermediate, two varieties.		about 1874; Rehder, 1927	(66)		1
characteristics of both parents; increased vigor, hardiness.	U.S.A., Ind., Mo.	Jones & Filley, 1920	(105)		2
cultivated.		b. 1910; Rehder, 1927	(66)		1
cultivated.		b. 1900; Rehder, 1927	(66)		2
cultivated.		b. 1919; Rehder, 1927	(66)		3
cultivated.		b. 1919; Rehder, 1927	(66)		4
cultivated.		b. 1920; Rehder, 1927	(66)		5
fertile.	Denmark	Raunkiaer, 1925; Larsen, 1937	(52)	26, 55, 66.	1
parentage not certain.		b. 1880; Rehder, 1927	(66)	26, 55.	2
cultivated 1871; parentage not certain.		Rehder, 1927	(66)	26, 55.	3
parentage not certain.		b. 1880; Rehder, 1927	(66)	26, 55.	4
parentage not certain.		about 1830; Rehder, 1927	(66)		5
intermediate in cone and seed characters.	England	Jackson & Dallimore, 1926	(104)		1
	U.S.A., Brazoria, Texas	Rehder, 1927	(66)	67.	1
cultivated since 1838.		Rehder, 1927	(66)		1
cultivated since 1900.		Rehder, 1927	(66)		2
cultivated since 1900.		Rehder, 1927	(66)		3
resembles *J. règia*; very vigorous; largest walnut tree.	Europe; U.S.A.	1863; Larsen, 1937	(52)	29, 65, 66, 67, 75, 100.	1
resembles *J. regia*.	Europe; U.S.A.	Sargent, 1921	(67)	29, 52, 66, 100.	2
100 ft. high, 9 ft. in circumference in 16 years.	U.S.A., Cal.	1877; Burbank	(52)	27, 29, 64, 66, 67, 73, 100, 106.	3
80 ft. high, 6 ft. in circumference in 15 years.	U.S.A., Cal.	1887; Burbank	(52)	27, 29, 64, 66, 100, 106.	4
intermediate; definite hybrid vigor.	Denmark; U.S.A.	1903; 1929; Rehder, 1927	(66)	29, 51, 52, 65, 67, 100, 101	5
nut resembles *J. Sieboldiana*; meiosis very irregular.		1878; Rehder, 1927	(66)	29, 65, 100.	6
represents a backcross (see No. 3).	U.S.A., Cal.	Schreiner, 1937	(73)	27, 64.	7
	U.S.A., Cal.	Schreiner, 1937	(73)	29, 100.	8
	U.S.A., Cal.	Schreiner, 1937	(73)	29, 100.	9
J. mandshurica characters dominant; greater vigor than *J. mandshurica*.	Russia	Yablokov, 1936	(101)	29, 100.	10
variable; winter hardy.	Russia	Yablokov, 1936	(101)	29, 100.	11
	Russia	Yablokov, 1936	(101)	29, 100.	12
	Russia	Yablokov, 1936	(101)	29, 100.	13
	Russia	Yablokov, 1936	(101)	29, 100.	14
	U.S.A.; East	Reed, 1936	(65)	29, 100.	15
	U.S.A.; East	Reed, 1936	(65)	29, 100.	16

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	LARIX ADANS. LARCH			
1	*L. Gmelini* Gord. × *L. sibirica* Ledeb.	N		× *L. Czekanowskii* Szafer
2	*L. Kaempferi* Sarg. × *L. decidua* Mill.	N, A	12 × 12	× *L. eurolepis* Henry (Dunkeld larch)
3	*L. Gmelini* Pilg. × *L. Kaempferi* Sarg.	N, A	× 12	
4	*L. decidua* Mill. × *L. Kaempferi* Sarg.	A	12 × 12	
5	*L. decidua* Mill. × *L. laricina* K. Koch	A	12 × 12	
6	*L. decidua* Mill. × *L. occidentalis* Nutt.	A	12 × 12	
7	*L. Kaempferi* Sarg. × *L. Gmelini olgensis* Ostf. & Lars.	N, A	12 ×	
8	*L. laricina* K. Koch × *L. decidua* Mill.	A	× 12	× *L. pendula* Salisb.
9	*L. leptolepis* × *L. europaea* (syn. with cross 2?)	?		Stabrand
10	*L. decidua* Mill. × *L. leptolepis* Murr. (syn. with cross 4?)		12 ×	
11	*L. occidentalis* Nutt. × *L. Lyallii*	N	12 ×	
12	*L. Potaninii* × *L. Mastersiana*	N		
	MAGNOLIA L. MAGNOLIA			
1	*M. virginiana* L. × *M. tripetala* L.	N	19 × 45	× *M. major* or *Thompsoniana* Sarg.
2	*M. denudata* Desr. × *M. Campbellii*		48 (57) ×	× *M. Veitchii* Bean
3	*M. stellata* Maxim. × *M. kobus* Thunb.			× *M. Loebneri* Kache
4	*M. denudata* Desr. × *M. liliflora* Desr.		48 (57) × 38	× *M. Soulangeana* Soul.
5	*M. denudata* × *M. liliflora*		57 × 38	× *M. purpurascens*
	PICEA DIETR. SPRUCE			
1	*P. sitchensis* Carr. × *P. canadensis* B.S.P.	N, A		
2	*P. Engelmanni* Englm. × *P. sitchensis* Carr.			
3	*P. Engelmanni* Englm. × *P. canadensis* B.S P.			
4	*P. rubra* Link. × *P. excelsa* Link.	A		
5	*P. mariana* B.S.P. × *P. jezoensis* Maxim.	R	12 ×	× *P. moseri* Mast.
6	*P. Glehnii* (Fr. Schm.) Mast. × *P. jezoensis* var. *hondoensis* (Mayr) Rehd.	N		× *P. notha* Rehd.
	PINUS DUHAM. PINE			
1	*P. mugo* Turra. × *P. sylvestris* L.	N	× 12	× *P. rhaetica* Bruegg.
2	*P. nigra* Arnold × *P. sylvestris* L.	N	12 × 12	× *P. neilreichiana*
3	*P. sylvestris* L. × *P. nigricans*	A	12 ×	
4	*P. montana* Mill. × *P. sylvestris* L.	N		× *P. rhaetica*
5	*P. palustris* × *P. taeda*	N		× *P. Sondereggeri*
6	*P. rigida* × *P. echinata*	N	× 12	
7	*P. Murrayana* × *P. Banksiana*	N	× 12	
8	*P. halepensis* × *P. pinaster*	N		
9	*P. nigra* × *P. densiflora*	A	12 ×	
10	*P. sylvestris* × *P. nigra*	A	× 12	
11	*P. montana* × *P. nigra*	N	× 12	× *P. Wettsteiniana*
12	*P. attenuata* × *P. radiata*	A		
13	*P. ayacahuite* Ehrenb. × *P. excelsa* Wall.	N		× *P. Holfordiana* Jacks.
14	*P. palustris* × *P. caribaea*	A		

Notes on hybrid	Country or region	Author and date of report or of origin	Other references	No.
fertile, intermediate.	Russia, E. Siberia	Szafer; Sukatschew (52)	53.	1
fertile, intermediate; extraordinarily vigorous growth.	England, Scotland, Denmark	1900; Henry & Flood, 1919 (40)	51, 52, 53, 66, 71, 73.	2
fertile; "large, handsome."	Denmark	Larsen, 1900 (52)	51, 53, 71, 73.	3
	Denmark; U.S.A.	Larsen, 1937 (52)	53, 71.	4
	Denmark; U.S.A.	Larsen, 1937 (52)	53, 71	5
F_1 triploid (n=18); vigorous, robust growth.	Denmark, U.S.A.	Larsen, 1937 (52)	53, 71.	6
	Denmark, U.S.A.	Larsen, 1937 (52)	53, 71.	7
resembles *L. laricina.*	Denmark, U.S.A.	Larsen, 1937 (52)	53, 66, 71.	8
L. leptolepis dominant in hardiness, vigor; compares favorably with Dunkeld larch.	Denmark	Pedersen, 1933 (61)	73.	9
	England	Anonymous, 1935 (2)	71.	10
hybridity probable.		Ostenfeld & Larsen, 1930 (60)	53.	11
hybridity probable.		Ostenfeld & Larsen, 1930 (60)	53.	12
intermediate.	England; U.S.A.	1808; Sargent, 1921 (67)	22, 27, 56, 66.	1
		1907; Rehder, 1927 (66)	1, 27, 87, 103.	2
"doubtful".		b. 1910; Rehder, 1927 (66)		3
		1820; Rehder, 1927 (66)	1, 27, 87, 103.	4
$F_1 2n=95$.	Japan	Yasui, K., 1937 (103)		5
pronounced hybrid vigor.	N. Europe, especially Denmark	Fabricius, 1926 (52)	51, 73.	1
	Denmark	1934; Larsen, 1937 (52)	51.	2
	Denmark	1934; Larsen, 1937 (52)	51, 73.	3
	U.S.A., N.Y.	1932; Heimburger (73)	47.	4
		Rehder, 1927 (66)	71.	5
clearly intermediate.	U.S.A., Mass.	1894; Rehder, 1939 (109)		6
fertile; intermediate; several forms.	Germany	Beissner, 1909; Petersen (52)	66, 71.	1
fertile.	Europe	Larsen, 1937 (52)	4, 71, 73.	2
see No. 10.	Germany	Klotzsch, 1854 (52)	71.	3
artificial crosses failed.	Denmark, (N. Jutland)	Larsen, 1934 (51)	3, 4, 73.	4
intermediate.	U.S.A., La.	Chapman, 1924 (14)	3, 4, 73.	5
	U.S.A., Pa.	Perry (4)	71.	6
	Canada, N. Alta.	Holman (4)	71.	7
	U.S.A.	Austin, 1929 (4)	3, 73.	8
	U.S.A.	1914; Blakeslee (4)	3, 71.	9
see No. 3	Germany	1845; Klotzsch (4)	3, 71.	10
	Germany	Austin, 1929 (4)	3, 71, 73.	11
hardiness of *P. attenuata;* vigor of *P. radiata;* F_1 produced.	U.S.A., Cal.	Austin, 1937 (5)	73.	12
seed and cone characters intermediate in general.	England	Jackson, 1933 (45)		13
types resistant to brown spot.	U.S.A., New Orleans, La.	Schreiner, 1937 (73)		14

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	PINUS DUHAM. PINE (Continued)			
15	*P. Sondereggeri* × *P. palustris*	A		
16	*P. Sondereggeri* × *P. taeda*	A		
17	*P. caribaea* × *P. taeda*	N		
18	*P. echinata* × *P. taeda*	N	12 ×	
19	*P. ponderosa* Jeffreyi × *P. ponderosa*		× 12	
20	*P. rigida* × *P. taeda*	N	12 ×	
	PLATANUS L. PLANE-TREE, SYCAMORE			
1	*P. orientalis* L. × *P. occidentalis* L.	N	10-11 (8) × 10-11 (8)	× *P. acerifolia* Willd.
	POPULUS L. POPLAR			
1	*P. alba* L. × *P. tremula* L.	N, A, R	19 × 19 (4)	× *P. canescens* Sm.
2	*P. balsamifera L.* × *P. nigra* L.	N	19 (38) × 19	× *P. canadensis* Moench.
3	*P. laurifolia* Ledeb. × *P. nigra* var. *italica* Dur.	N	× 19	× *P. berolinensis* Dippel.
4	*P. angulata* Ait. × *P. nigra* var. *plantierensis* Schneid.	N, A	× 19	× *P. robusta* Schneid.
5	*P. angulata* Ait. × *P. trichocarpa* Torr. & Gray	A, R	× 19	× *P. generosa* Henry
6	*P. pyramidalis* × *P. nigra*	N	× 19	× *P. charkowiensis*
7	*P. deltoides* var. *monilifera* × *P. nigra* var. *typica*	N	× 19	× *P. serotina*
8	*P. nigra* × *P. serotina*	N	19 × 19	× *P. regenerata*
9	× *P. regenerata* × *P. nigra* var. *italica*	N	× 19	× *P. Eugenei*
10	*P. balsamifera virginiana* × *P. grandidentata*	A	× 19	
11	*P. acuminata* Rydb. × *P. Sargentii* Dode.	N, R		× *P. Andrewsii* Sarg.
12	*P. Fremontii* S. Wats. × *P. trichocarpa* Hook.	N	× 19	× *P. Parryi* Sarg.
13	*P. balsamifera virginiana* Sarg. × *P. tacamahaca* Mill.	N		× *P. Jackii* Sarg.
14	× *P. canescens* Sm. × *P. tremula* L.	A	19 × 19 (4)	
15	*P. angulata* Späth × *P. canadensis*		× 4	× *P. eucalyptus*
16	*P. canadensis* × *P. pyramidalis*		4 ×	
17	*P. canescens* Sm. × *P. tremuloides* Michx.	A	19 × 19	
18	*P. laurifolia* Ledeb. × *P. balsamifera* L. (?)	N		× *P. Petrowskyana* Schneid.
19	*P. laurifolia* Ledeb. × *P. nigra* L.	N		× *P. Rasumowskyana* Schneid.
20	*P. laurifolia* Ledeb. × *P. tristis* Fisch.	N		× *P. Wobstii* Schroed.
21	*P. alba* L. × *P. tremuloides* Michx.	A	19 (?) × 19	
22	*P. alba* L. × *P. grandidentata* Michx.	A, N	19 (?) × 19	
23	*P. canescens* Sm. × *P. grandidentata* Michx.	A	19 (?) × 19	
24	*P. tremuloides* Michx. × *P. grandidentata* Michx.	A	19 × 19	
25	*P. alba* × *P. alba nivea*	A	19 × 19	
26	*P. alba* × *P. canescens*	A	19 × 19	
27	*P. alba* × *P. adenopoda*	A	19 ×	

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
backcross.	U.S.A., New Orleans	Schreiner, 1937	(73)		15
backcross.	U.S.A., New Orleans	Schreiner, 1937	(73)		16
hybridity probable; ten trees.	U.S.A., Cal.	Schreiner, 1937	(73)		17
vigor exceeds *P. echinata*; hybridity probable; 14 trees.	U.S.A., Cal.	Schreiner, 1937	(73)	71.	18
vigor greatly exceeds *P. p. Jeffreyi*; hybridity certain.	U.S.A., Cal.	Schreiner, 1937	(73)	71.	19
hybridity probable, four trees.	U.S.A., Cal.	Schreiner, 1937	(73)	71.	20
fertile; London plane-tree; hardy; $F_1n=10\text{–}11$ (21).	Eng.; Europe generally	b. 1700; Larsen, 1937	(52)	11, 12, 27, 66, 70, 96.	1
fertile; most vigor where *P. alba* is female; $F_1n=19$.	Central Europe; U.S.A.	Wettstein, 1934	(89)	9, 27, 30, 33, 52, 63, 78, 90.	1
fertile; also var. *Eugenei* Schelle; $F_1n=4$.	Europe, N. Amer.	Rehder, 1927	(66)	9, 26, 27, 33, 52, 67.	2
fertile; hardy, N.W. prairies; original female from Germany.	Europe	b. 1870; Dippel, 1892	(13)	9, 26, 52, 66.	3
male only; very rapid growth.	France; U.S.A.	1895; Schneider, 1904	(13)	9, 26, 52, 66, 78.	4
very rapid growth; $F_1n=19$.	England, U.S.A.	1900, 1912; Henry, 1914	(13)	8, 26, 27, 52, 57, 66, 78.	5
intermediate; rapid growth, hardy	Russia (Charkow)	Kucera, 1902	(13)	9, 26.	6
male only; very rapid growth; frost hardy $F_1n=19$.	France	Duhamel, 1755	(13)	8, 9, 26, 27.	7
female only; leaves and branches as *P. ser.*; very rapid growth.	France (Arcueil)	1814; Henry, 1913	(13)	8, 9, 26, 27.	8
male only; $F_1n=19$, canker susceptible.	France (Metz)	1832; Schneider, 1904	(13)	8, 9, 26, 27, 63.	9
P. grand. dominant in nearly all characters; vigor very variable.	U.S.A. (N. East)	Stout & Schreiner, 1934	(79)	9, 26, 63, 78.	10
intermediate; introduced U.S.A. 1913.	U.S.A., Colorado	Sargent, 1921	(67)	66.	11
intermediate.	U.S.A., Cal.	Sargent, 1921	(67)	26, 57.	12
intermediate; introduced U.S.A. 1900; cultivated occasionally.	U.S.A. Mich., Vt.; Can., Que.	Sargent, 1921	(67)	66.	13
less vigor than *P. canescens*; backcross.	Germany	Wettstein, 1937	(90)	9, 26, 27, 33, 63.	14
more vigor than *P. can.*; resistant to *Melampsora populini* in F_2.	Germany	Wettstein, 1937	(90)	27, 33, 91.	15
P. pyramidalis dominant.	Germany	Wettstein, 1937	(90)	27, 33.	16
F_1 died as small seedling.	Canada, Ont.	Heimburger, 1936	(38)	20, 27, 63, 73.	17
P. laur. as parent doubtful.	U.S.A.; Canada	b. 1882; Rehder, 1927	(66)		18
P. laur. as parent doubtful.	U.S.A.; Canada	b. 1882; Rehder, 1927	(66)		19
similar to *P. laurifolia*.	U.S.A.	Rehder, 1927	(66)		20
F_1 died as small seedling.	Canada, Ont.	Heimburger, 1936	(38)	20, 27, 47, 63.	21
intermediate.	Ont., Canada	Heimburger, 1936	(38)	47, 63.	22
characters very variable.	Ont., Canada	Heimburger, 1936	(38)	63.	23
intermediate.	Ont., Canada	Heimburger, 1936	(38)	20, 27, 63.	24
67 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	63.	25
8 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	63.	26
34 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	63.	27

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	POPULUS L. POPLAR (Continued)			
28	*P. alba* × *P. tremula Davidiana*	A	19 ×	
29	*P. tremuloides* × *P. tremula*	A	19 × 19	
30	*P. angulata* × *P. balsamifera virginiana*	A		
31	*P. angulata* × Cottonwood (unidentified)	A		
32	*P. angulata* × *P. caudina*	A		
33	*P. angulata* × *P. incrassata*	A		
34	*P. angulata* × clone Robusta	A		
35	*P. angulata* × clone Volga	A		
36	*P. angulata* × *P. berolinensis*	A		
37	*P. angulata* × *P. trichocarpa*	A	× 19	
38	*P. balsamifera virginiana* × Cottonwood (unidentified)	A		
39	*P. balsamifera virginiana* × *P. caudina*	A		
40	*P. balsamifera virginiana* × *P. incrassata*	A		
41	*P. balsamifera virginiana* × *P. nigra plantierensis*	A		
42	*P. balsamifera virginiana* × clone Robusta	A		
43	*P. balsamifera virginiana* × clone Volga	A		
44	*P. balsamifera virginiana* × *P. berolinensis*	A		
45	*P. balsamifera virginiana* × *P. trichocarpa*	A	× 19	
46	*P. charkowiensis* × *P. balsamifera virginiana*	A		
47	*P. charkowiensis* × Cottonwood (unidentified)	A		
48	*P. charkowiensis* × *P. caudina*	A		
49	*P. charkowiensis* × *P. incrassata*	A		
50	*P. charkowiensis* × *P. nigra plantierensis*	A		
51	*P. charkowiensis* × clone Robusta	A		
52	*P. charkowiensis* × clone Volga	A		
53	*P. charkowiensis* × *P. berolinensis*	A		
54	*P. charkowiensis* × *P. trichocarpa*	A	× 19	
55	*P. Fremontii* × *P. balsamifera virginiana*	A		
56	*P. Fremontii* × Cottonwood (unidentified)	A		
57	*P. Fremontii* × *P. incrassata*	A		

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
16 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	63.	28
11 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 20, 27, 63.	29
583 seedlings; susceptible to rust.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		30
248 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		31
99 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		32
203 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		33
60 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		34
214 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		35
205 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		36
264 seedlings, 1 very promising. (See No. 5).	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	37
18 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		38
189 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		39
208 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		40
183 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		41
7 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		42
216 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		43
245 seedlings, 3 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		44
705 seedlings, 3 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	45
288 seedlings, 4 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		46
267 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		47
266 seedlings, 5 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		48
263 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		49
312 seedlings, 2 very promising; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		50
52 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		51
188 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		52
249 seedlings, 3 very promising; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		53
221 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	54
7 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933.	(78)		55
9 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		56
108 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		57

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	***POPULUS* L. POPLAR (Continued)**			
58	*P. Fremontii* × *P. nigra plantierensis*	A		
59	*P. Fremontii* × clone Volga	A		
60	*P. Fremontii* × *P. berolinensis*	A		
61	*P. Fremontii* × *P. trichocarpa*	A	× 19	
62	*P. nigra* × clone Eugenei	A	19 × 19	
63	*P. nigra* × *P. nigra Italica* (clone Lombardy)	A	19 ×	
64	*P. nigra* × *P. berolinensis Rossica*	A	19 ×	
65	*P. nigra* × *P. laurifolia*	A	19 ×	Frye, Rumford, Strathglass
66	*P. nigra* × *P. Simonii*	A	19 × 38	
67	*P. nigra* × *P. trichocarpa*	A	19 × 19	Roxbury
68	*P. nigra baatanicorum vitrum* × *P. balsamifera virginiana*	A		
69	*P. nigra baatanicorum vitrum* × Cottonwood	A		
70	*P. nigra baatanicorum vitrum* × *P. caudina*	A		
71	*P. nigra baatanicorum vitrum* × *P. incrassata*	A		
72	*P. nigra baatanicorum vitrum* × *P. nigra plantierensis*	A		
73	*P. nigra baatanicorum vitrum* × clone Volga	A		
74	*P. nigra baatanicorum vitrum* × *P. trichocarpa*	A	× 19	
75	*P. nigra betulifolia* × *P. balsamifera virginiana*	A		
76	*P. nigra betulifolia* × Cottonwood	A		
77	*P. nigra betulifolia* × *P. incrassata*	A		
78	*P. nigra betulifolia* × *P. nigra plantierensis*	A		
78	*P. nigra betulifolia* × clone Volga	A		
80	*P. nigra betulifolia* × *P. trichocarpa*	A	× 19	Andover
81	*P. Sargentii* × *P. balsamifera virginiana*	A		
82	*P. Sargentii* × clone Eugenei	A	× 19	
83	*P. Sargentii* × *P. nigra Italica* (clone Lombardy)	A		
84	*P. Sargentii* × *P. berolinensis*	A		
85	*P. Sargentii* × *P. berolinensis Rossica*	A		
86	*P. Sargentii* × *P. laurifolia*	A		
87	*P. Sargentii* × *P. Simonii*	A	× 38	

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
194 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		58
217 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		59
69 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		60
125 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	61
49 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	8, 9, 26, 27, 63.	62
44 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 26.	63
217 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 26.	64
377 seedlings, 10 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 26, 80.	65
2 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 26, 57.	66
200 seedlings; 3 very promising; remarkable vigor.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	9, 26, 57, 80.	67
6 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		68
60 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		69
51 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		70
10 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		71
157 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		72
170 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		73
121 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	74
11 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		75
11 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		76
141 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		77
65 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		78
166 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		79
209 seedlings, 1 very promising; remarkable vigor; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57, 80.	80
72 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		81
50 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	8, 27, 63.	82
25 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		83
149 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		84
309 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		85
51 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		86
14 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	26, 57.	87

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	***POPULUS* L. POPLAR (Continued)**			
88	*P. Sargentii* × *P. trichocarpa*	A	× 19	
89	*P. berolinensis* × *P. caudina*	A		
90	*P. berolinensis* × *P. nigra plantierensis*	A		
91	*P. berolinensis* × clone Serotina	A	× 19	
92	*P. berolinensis* × clone Volga	A		
93	*P. berolinensis* × *P. trichocarpa*	A	× 19	
94	*P. Maximowiczii* × *P. caudina*	A		
95	*P. Maximowiczii* × *P. incrassata*	A		
96	*P. Maximowiczii* × *P. nigra plantierensis*	A		Rochester
97	*P. Maximowiczii* × *P. berolinensis*	A		Geneva, Oxford
98	*P. Maximowiczii* × *P. trichocarpa*	A	× 19	Androscoggin
99	*P. Petrowskyana* × *P. caudina*	A		
100	*P. Rasumowskyana* × *P. grandidentata*	A	× 19	
101	*P. Rasumowskyana* × *P. balsamifera virginiana*	A		
102	*P. Rasumowskyana* × Cottonwood (unidentified)	A		
103	*P. Rasumowskyana* × *P. caudina*	A		
104	*P. Rasumowskyana* × *P. incrassata*	A		
105	*P. Rasumowskyana* × *P. nigra plantierensis*	A		
106	*P. Rasumowskyana* × clone Volga	A		
107	*P. Rasumowskyana* × *P. berolinensis*	A		
108	*P. Rasumowskyana* × *P. trichocarpa*	A	× 19	
109	*P. Simonii* × *P. grandidentata*	A	38 × 19	
110	*P. Simonii* × *P. caudina*	A	38 ×	
111	*P. Simonii* × *P. incrassata*	A	38 ×	
112	*P. Simonii* × *P. nigra plantierensis*	A	38 ×	
113	*P. Simonii* × clone Robusta	A	38 ×	
114	*P. Simonii* × clone Volga	A	38 ×	
115	*P. Simonii* × *P. berolinensis*	A	38 ×	
116	*P. Simonii* × *P. trichocarpa*	A	38 × 19	

Notes on hybrid	Country or region	Author and date of report or of origin	Other references	No.
233 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	88
8 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		89
17 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		90
29 seedlings	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	8, 27.	91
62 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		92
27 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57	93
179 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		94
2 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		95
145 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	80.	96
112 seedlings; very vigorous; rust resistant; late, fall growth; 8 very prominent.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	80.	97
5 seedlings, 3 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57, 80.	98
25 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		99
2 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	63.	100
56 seedlings.	U.S.A (N. East)	Stout & Schreiner, 1933 (78)		101
30 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		102
70 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		103
25 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		104
76 seedlings; half of the hybrids are columnar.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		105
81 seedlings, 1 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		106
183 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)		107
148 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	108
32 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57, 63.	109
99 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	110
75 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	111
176 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	112
1 seedling.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	113
155 seedlings; pyramidal.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	114
189 seedlings, 1 very promising; columnar to spreading.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	115
44 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933 (78)	26, 57.	116

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	POPULUS **L.** POPLAR (Continued)			
117	*P. tacamahaca candicans* (clone Balm of Gilead) × *P. balsamifera virginiana*	A		
118	*P. tacamahaca candicans* × *P. nigra plantierensis*	A		
119	*P. tacamahaca candicans* × *P. berolinensis*	A		Maine
120	*P. tacamahaca candicans* × *P. laurifolia*	A		
121	*P. nigra* × *P. deltoidea* var. *missouriensis*	N	19 ×	Carolina poplar
	QUERCUS **L.** OAK			
1	*Q. robur* L. × *Q. sessiliflora* Salisb.	N, A	12 (11) × 12 (11)	× *Q. rosacea* Bechst.
2	*Q. sessiliflora* Martyn. × *Q. robur* L.		12 × 12	
3	*Q. Cerris* L. × *Q. suber* L.	N	12 (11) × 12	× *Q. hispanica* Lam.
4	*Q. robur* Mill. × *Q. pedunculata* (*Q. robur* L.)	A	× 12 (11)	
5	*Q. Ilex* L. × *Q. suber* P. Cout.		12 × 12	
6	*Q. coccifera* L. × *Q. Ilex* L.		12 × 12	
7	*Q. robur* L. (*pedunculata*) × *Q. macrocarpa*		12 (11) × 12 (6)	
8	*Q. Ilex* L. × *Q. sessilis* Ehrh. (*sessiliflora* Salisb.)		12 × 11	× *Q. Koehnii*
9	*Q glaucophylla* Seemen × *Q. clivicola* Trel. & C. H. Muell.	N		× *Q. pastorensis* C. H. Muell.
10	*Q. breviloba* (Torr.) Sarg. × *Q. stellata* Wang.	N		× *Q. Mahoni* E. J. Palmer
11	*Q. prinoides* Willd. × *Q. stellata* Wang.	N	6 ×	× *Q. stelloides* E. J. Palmer
12	*Q. robur* L. × *Q. Ilex* L.	N	11 × 12	× *Q. Turneri* Willd.
13	*Q. Ilex* L. × *Q. sessiliflora*	N	12 × 12	× *Q. andleyensis* Henry
14	*Q. montana* Willd. × *Q. robur* L.	N	12 × 11	× *Q. Sargentii* Rehd.
15	*Q. macrocarpa* Michx. × *Q. undulata* Torrey	N	12 (6) ×	× *Q. Andrewsii* Sarg.
16	*Q. prinus* L. × *Q. macrocarpa* Michx.	N	× 6 (12)	× *Q. byarsii* Sudw.
17	*Q. virginiana* Miller × *Q. macrocarpa* Michx.	N	× 6 (12)	× *Q. coloradensis* Ashe
18	*Q. lyrata* Walter × *Q. virginiana* Miller	N, A		× *Q. Comptonae* Sarg.
19	*Q. virginiana* × *Q. lyrata*			
20	*Q. alba* L. × *Q. Muehlenbergii* Engel.	N	12 (6) × 6 (12)	× *Q. Deamii* Trel.
21	*Q. alba* L. & *Q. stellata* Wang.	N	12 (6) ×	× *Q. Fernowii* Trel.
22	*Q. macrocarpa* Michx. × *Q. stellata* Wang.	N	12 (6) ×	× *Q. guadalupensis* Sarg.
23	*Q. stellata Margaretta* (Ashe) Sarg. × *Q. virginiana geminata* (Small) Sarg.	N		× *Q. Harbisonii* Sarg.
24	*Q. macrocarpa* Michx. × *Q. Muehlenbergii* Engel.	N	6 (12) × 6 (12)	× *Q. Hillii* Trel.
25	*Q. Douglasii* Hook. & Arn. × *Q. lobata* Nee	N		× *Q. jolonensis* Sarg.
26	*Q. durandii* Buckl. × *Q. stellata* E. J. Palmer	N		× *Q. Macnabiana* Sudw.

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
6 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		117
40 seedlings.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)		118
82 seedlings, 2 very promising.	U.S.A. (N. East)	Stout & Schreiner, 1933	(78)	80.	119
6 seedlings.	U.S.A. (N. East)	Stout & Sehreiner, 1933	(78)		120
very rapid growth.	Europe, N. America	Lamb, 1916	(105)	9, 26.	121
fertile; intermediate; hybrid vigor variable; cultivated.	Germany	Klotzsch, 1854;	(52)	27, 28, 29, 44, 46, 66, 93, 94.	1
		Geschwind, 1876	(44)	28, 29, 46, 94.	2
fertile; several named varieties; vigorous growth; $F_1n=12$.	Europe, especially England	1765; Lamb, 1916	(105)	27, 28, 29, 32, 46, 52, 59, 66, 73, 74, 93, 94.	3
	Germany	Klotzsch, 1854	(52)	27, 28, 29, 44, 46, 93, 94.	4
	Spain	Natividade, 1937	(59)	28, 29, 31, 32.	5
	Spain	Natividade, 1937	(59)	28, 29, 31, 32.	6
hybrid vigor observed.	Russia	Kolesnikov, 1933	(48)	25, 27, 28, 29, 44, 46, 68, 93, 94.	7
also *Q. andleyensis* Henry; $F_1n=12$ (11).	Europe	Wetzel, 1929	(94)	27, 28, 29, 32, 46, 66, 93.	8
backcrossing probable; hybrid vigor not observed.	Mexico	Mueller, 1936	(106)		9
intermediate.	U.S.A. (S W.)	Palmer, 1937	(107)		10
intermediate in leaf characters.	U.S.A. (Mid W.)	Palmer, 1937	(107)	25, 29	11
var. *pseudoturneri* Henry.	England	b. 1785; Rehder, 1927	(66)	27, 29, 32, 74, 93.	12
parentage not certain.	Europe	Rehder, 1927	(66)	28, 29, 31, 32, 44.	13
differs from *Q. montana* chiefly by auriculate base of leaf and fewer lobes; very vigorous.	U.S.A.	b. 1830; Rehder, 1927	(66)	27, 29, 68, 93.	14
intermediate.	U.S.A., W. Okla.	Sargent, 1921	(67)	25, 29, 68, 74.	15
	U.S.A., S.W. Tenn.	Schreiner, 1937	(74)	25, 29, 68.	16
	U.S.A., E. Texas	Schreiner, 1937	(74)	25, 29, 68.	17
intermediate; cultivated; up to 100 ft. in height; see No. 19.	U.S.A., Ala., Miss., La., Texas	Sargent, 1921	(67)	74.	18
intermediate; partial fertility; hybrid vigor for fruit size; F_2 produced. See No. 18.	U.S.A.	1909; Yarnell, 1933	(102)		19
intermediate; introduced U.S.A. 1916.	U.S.A., Bluffton, Ind.	Sargent, 1921	(67)	25, 29, 66, 68, 74.	20
introduced U.S.A. b. 1898.	U.S.A., Ill., Md., Va., Miss.	Sargent, 1921	(67)	25, 29, 66, 68, 74.	21
intermediate.	U.S.A., S.E. Texas	Sargent, 1921	(67)	25, 29, 68, 74.	22
one tree.	U.S.A., Jacksonville, Fla.	Sargent, 1921	(67)	74.	23
	U.S.A., Ind., Mo.	Sargent, 1921	(67)	25, 29, 68, 74.	24
intermediate.	U.S.A., Jolon, Cal.	Sargent, 1921	(67)	74.	25
one tree.	U.S.A., Hampstead Co., Ark.	Schreiner, 1937	(74)		26

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	QUERCUS **L.** OAK (Continued)			
27	*Q. arizonica* Sarg. × *Q. grisea* Liebmann.	N		× *Q. organensis* Trel.
28	*Q. dumosa* Nutt. × *Q. Engelmannii* Greene	N		× *Q. Macdonaldii* Greene
29	*Q. alba* L. × *Q. Prinus* L.	N	12 (6) × 6	× *Q. Beadlei* Trel.
30	*Q. alba* L. × *Q. macrocarpa* Michx.	N	12 (6) × 12 (6)	× *Q. Bebbiana* Schn.
31	*Q. alba* × *Q. macrocarpa*	N	12 (6) × 12 (6)	× *Q. Bebbiana Orpheusi*
32	*Q. alba* L. × *Q. prinoides*	N	12 (6) × 6	× *Q. Faxonii* Trel.
33	*Q. alba* × *Q. bicolor* Willd.	N	12 (6) × 12	× *Q. Jackiana* Schn.
34	*Q. alba* L. × *Q. montana* L.	N	12 (6) × 12	× *Q. Saulei* Schn.
35	*Q. bicolor* Willd. × *Q. macrocarpa* Michx.		12 × 6 (12)	× *Q. Schuettii* Trel.
36	*Q. Catesbaei* Michx. × *Q. cinerea* Michx.	N		× *Q. Ashei* Trelease
37	*Q rhombica* Sarg. × *Q. rubra* L.	N		× *Q. beaumontiana* Sarg.
38	*Q. cinerea* Michx. × *Q. laurifolia* Michx.	N		× *Q. atlantica* Ashe
39	*Q. Catesbaei* Michx. × *Q. rubra* L.			× *Q. blufftonensis* Trelease
40	*Q. marilandica* Muench. × *Q. velutina* Lam.	N	6 × 6 (12)	× *Q. Bushii* Sarg.
41	*Q. cinerea* Michx. × *Q. nigra* L.	N	× 11 (12)	× *Q. caduca* Trelease
42	*Q. marilandica* Muench. × *Q. cinerea* Michx.	N	6 ×	× *Q. caroliniensis* Trelease
43	*Q. rhombica* Sarg. × *Q. velutina* Lam.	N	×16 (12)	× *Q. Cocksii* Sarg.
44	*Q. imbricaria* Michx. × *Q. palustris* Engel.	N	12 × 12	× *Q. exacta* Trelease
45	*Q. ilicifolia* Wang. × *Q. Phellos* L.	N		× *Q. Giffordii* Trel.
46	*Q. marilandica* Muench. × *Q. texana* Buckl.	N	6 ×	× *Q. Hastingsii* Sarg.
47	*Q. borealis maxima* (Marsh.) Ashe × *Q. velutina* Lam.	N	6 × 6 (12)	× *Q. Hawkinsii* Sudw.
48	*Q. imbricaria* Michx. × *Q. velutina* Lam.	N	× 6 (12)	× *Q. Leana* Nuttall
49	*Q. rubra pagodaefolia* (Elliott) Ashe × *Q. Phellos* L.	N		× *Q. ludoviciana* Sarg.
50	*Q. Wislizenii* A. DC. × *Q. Kelloggii* Newb.	N		× *Q. morehus* Kellogg
51	*Q. Phellos* L. × *Q. rubra* L.	N		× *Q. subfalcata* Trel.
52	*Q. nigra* L. × *Q. Shumardii* N. J. Palmer	N	11 (12) ×	× *Q. neopalmeri* Sudw.
53	*Q. cinerea* Michx. × *Q. myrtifolia* Willd.	N		× *Q. oviedoensis* Sarg.
54	*Q. ellipsoidalis* E. J. Hill × *Q. velutina* Lam.	N	× 6 (12)	× *Q. paleolithicola* Trel.
55	*Q. borealis maxima* (Marsh.) Ashe × *Q. imbricaria*	N	6 ×	× *Q. runcinata* (A. DC.) Engel.
56	*Q. georgiana* M. A. Curtis × *Q. marilandica* Muench.	N	× 6	× *Q. Smallii* Trel.
57	*Q. marilandica* Muench. × *Q. nigra* L.	N	6 × 11 (12)	× *Q. sterilis* Trel.
58	*Q. cinerea* Michx. × *Q. rubra* L.	N		× *Q. subintegra* Trel.
59	*Q. rubra* L. × *Q. velutina* Lam.	N	× 6 (12)	× *Q. Sudworthii* Trel.
60	*Q. marilandica* Muench. × *Q. imbricaria* Michx.	N	6 ×	× *Q. tridentata* Engel.
61	*Q. arkansana caput-rivuli* Ashe × *Q. cinerea* Michx.	N		× *Q. venulosa* Ashe

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
	U.S.A., N.M.	Schreiner, 1937	(74)		27
intermediate shrub.	U.S.A., Cal.	Sargent, 1921.	(67)		28
	U.S.A., Clarkton, N.C.	Sargent, 1921	(67)	25, 29, 68.	29
introduced U.S.A. b. 1880.	U.S.A., Vt., Ohio	Sargent, 1921	(67)	25, 29, 66, 68.	30
	U.S.A., Col.	Schantz, 1934	(72)	25, 29, 68.	31
intermediate.	U.S.A., Mass., Mich.	Sargent, 1921	(67)	25, 29, 68.	32
introduced U.S.A. 1916.	U.S.A., Boston, Mass.	Sargent, 1921	(67)	25, 29, 66, 68.	33
intermediate.	mainly N.E. U.S.A.	Sargent, 1921	(67)	25, 29, 66, 68.	34
leaves intermediate.	U.S.A., Wis.; Can., Que.	Sargent, 1921	(67)	25, 29, 66, 68.	35
	U.S.A., Georgia	Sargent, 1921	(67)	74.	36
Schreiner (74) states parentage as being *Q. obtusa* × *Q. rubra*.	U.S.A., Beaumont, Texas	Sargent, 1921	(67)	74.	37
	U.S.A., Carolina coast	Schreiner, 1937	(74)		38
	U.S.A., Bluffton, S.C.	Sargent, 1921	(67)	74.	39
	U.S.A., Southern	Sargent, 1921	(67)	25, 29, 68, 74.	40
	U.S.A., Southern	Sargent, 1921	(67)	25, 27, 28, 29, 46, 74, 93, 94.	41
	U.S.A., Ga., Texas, N.C.	Sargent, 1921	(67)	25, 29, 74.	42
	U.S.A., Pineville, La.	Sargent, 1921	(67)	25, 29, 68, 74.	43
cultivated 1889.	U.S.A., Mo., Ill., Ind., Pa.	Sargent, 1921	(67)	28, 29, 31, 32, 66, 68, 74.	44
	U.S.A., May's Landing, N.J.	Sargent, 1921	(67)	74.	45
	U.S.A., central Texas	Sargent, 1921	(67)	25, 29, 74.	46
Hawkin's Oak, single tree.	U.S.A., Huntingdon, Tenn.	Schreiner, 1937	(74)	25, 29, 68.	47
cultivated; introduced U.S.A. b. 1850; Lea Oak.	U.S.A., D.C., N.C., Mich., Ill., Mo.	Sargent, 1921	(67)	25, 29, 66, 68, 74.	48
var. *microcarpa* Rehd.; $F_1 n=12$; single tree.	U.S.A., Peteville, La.	Sargent, 1921	(67)	29, 66, 68, 74.	49
	U.S.A., Cal.	Sargent, 1921	(67)	74.	50
var. *microcarpa* Sarg. of Dutch origin.	U.S.A., Ark., Texas, Ky., Ill., Miss.	Sargent, 1921	(67)	74.	51
single tree.	U.S.A., McNab, Ark.	Schreiner, 1937	(74)	27, 28, 29, 46, 93, 94.	52
	U.S.A., Oviedo, Fla.	Sargent, 1921	(67)	74.	53
	U.S.A., Mich., Ia., Ill.	Schreiner, 1937	(74)	25, 29, 68.	54
introduced U.S.A. 1883.	U.S.A., Mo., Ill.	Sargent, 1921	(67)	25, 29, 66, 74.	55
hybridity probable.	U.S.A., central Ga.	Sargent, 1921	(67)	25, 29, 74.	56
	U.S.A., Bladen Co., N.C.	Sargent, 1921	(67)	25, 27, 29, 28, 46, 74, 93, 94.	57
	U.S.A., coast Ga. to Fla.	Sargent, 1921	(67)	74.	58
also × *Q. Willdenoviana* Zabel.; single tree.	U.S.A., Covington, Tenn.	1880; Coffman	(74)	25, 29, 67, 68.	59
	U.S.A., Mo., Ill., Mich.	Sargent, 1921	(67)	25, 29, 74.	60
	U.S.A., Turkey Creek, Fla.	Schreiner, 1937	(74)		61

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	QUERCUS **L.** OAK (Continued)			
62	*Q. Catesbaei* Michx. × *Q. nigra* L.	N	× 11	× *Q. Walteriana* Ashe
63	*Q. borealis maxima* Ashe × *Q. velutina* Lam.	N	6 × 6 (12)	× *Q. Porterii* Trel.
64	*Q. coccinea* Muench. × *Q. ilicifolia* Wang.	N		× *Q. Robbinsii* Trel.
65	*Q. coccinea* Muench. × *Q. borealis maxima* Ashe	N	6 (4) × 6	× *Q. Benderi* Baenitz
66	*Q. ilicifolia* Wang. × *Q. marilandica* Muench.	N	× 6	× *Q. Brittonii* Davis
67	*Q. ilicifolia* Wang. × *Q. velutina* Lam.	N	× 6 (12)	× *Q. Rehderi* Trel.
68	*Q. marilandica* Muench. × *Q. Phellos* L.	N	6 ×	× *Q. Rudkinii* Brit.
69	*Q. cinerea* Michx. × *Q. laurifolia* Michx.	N		× *Q. sublaurifolia* Trel.
70	*Q. Phellos* L. × *Q. borealis maxima* Sarg.	N	× 6	× *Q. heterophylla* Michx.
71	*Q. Phellos* L. × *Q. palustris* L.	N	× 12	× *Q. Schochiana* Dieck
72	*Q. palustris* L. × *Q. borealis maxima* Sarg.	N	12 × 6	× *Q. Richteri* Boenitz
73	*Q. rubra pagodaefolia* Ashe × *Q. velutina* Lam.	N		× *Q. Willdenoviana* Zabel
74	*Q. Catesbaei* Michx. × *Q. laurifolia* Michx.	N		× *Q. Mellichampii* Trel.
75	*Q. borealis maxima* Ashe × *Q. ilicifolia* Wang.	N	6 ×	× *Q. Lowellii* Sarg.
76	*Q. imbricata* Michx. × *Q. borealis maxima* Ashe	N	× 6	× *Q. runcinata* Engelm.
77	*Q. bicolor* Willd. × *Q. lyrata* Walt.		12 ×	× *Q. humidicola* E. J. Palmer
	ROBINIA **L.** LOCUST			
1	*R. pseudoacacia* L. × *R. neo-mexicana luxurians* Dieck	N	10 (11) × 10	× *R. Holdtii* Beiss.
2	*R. Kelseyi* Hutchins. × *R. pseudoacacia* L.	N	10 × 10 (11)	× *R. Slavinii* Rehd.
3	*R. pseudoacacia* L. × *R. hispida* L.	N	11 × 15	× *R. Margaretta* Ashe
4	*R. viscosa* Vent. × *R. pseudoacacia* L.	N	× 11	× *R. ambigua* Poir.
	SALIX **L.** WILLOW			
1	*S. viminalis* L. × *S. caprea* L.	A	19 × 19 (38)	× *S. Smithiana* Willd.
2	*S. viminalis* L. × *S. purpurea* L.	N, A	19 × 19	× *S. rubra* Huds.; Harrison willow.
3	*S. phylicifolia* × *S. viminalis*		44 × 19	
4	*S. caprea* L. × *S. lanata*		19 × 19	
5	*S. aurita* L. × *S. phylicifolia* L.		38 × 44	× *S. ludificans* B. White
6	*S. cinerea* L. × *S. phylicifolia* L.	N	38 × 44	× *S. Wardiana* B. White
7	*S. repens* L. × *S. viminalis* L.	N	19 × 19	× *S. Friesiana* Anders.
8	*S. caprea viminalis* × *S. americana* Hort.	A		
9	*S. viminalis* × *S. americana* Hort.	A	19 ×	
10	*S. purpurea* × *S. americana* Hort.	A	19 ×	
11	*S. alba* × *S. gracilis*	N	38 ×	× *S. coerulea*

Notes on hybrid	Country or region	Author and date of report or of origin	Other references	No.
	U.S.A., S.C., Ga., N.C., Fla., Ala.	Sargent, 1921 (67)	27, 28, 74, 93, 94.	62
	U.S.A., Mass., Pa., Ohio	Sargent, 1921 (67)	25, 29, 68.	63
introduced U.S.A. 1913.	U.S.A., North Easton, Mass.	Sargent, 1921 (67)	25, 27, 28, 29, 15, 66, 93, 94.	64
buds and leaves intermediate; originated in Europe, found in Silesia.	U.S.A., Boston, Mass.	b. 1900; Sargent, 1921 (67)	15, 25, 27, 29, 28, 66, 93, 94.	65
	U.S.A., N.Y., N.J.	Sargent, 1921 (67)	25, 29.	66
introduced U.S.A. 1905.	U.S.A., Mass.	Sargent, 1921 (67)	25, 29, 66, 68.	67
intermediate.	U.S.A., N.Y., N.J., N.C.	Sargent, 1921 (67)	25, 29.	
	U.S.A., Ga., Miss.	Sargent, 1921 (67)		69
Q. velutina Lam. may be parent instead of *Q. borealis maxima* Sarg. Cultivated 1822.	U.S.A., N.J. to Tex.	Rehder, 1927 (66)	29, 25.	70
cultivated 1896.		Rehder, 1927 (66)	29, 68.	71
originated in Europe; occurs spontaneously with parents.	Europe, U.S.A.	b. 1900; Rehder, 1927 (66)	25, 29, 68.	72
parentage not certain.	Europe	Sargent, 1921 (67)		73
parentage not certain.	U.S.A., N.C., Fla.	Sargent, 1921 (67)		74
hybridity not certain.	U.S.A., Maine	Sargent, 1921 (67)	25, 29.	75
found with parents; introduced 1883.	Europe; U.S.A.	Rehder, 1927 (66)	25, 29.	76
intermediate.	U.S.A., Mo., Ill.	Palmer, 1937 (108)	29, 68.	77
chromosome pairing normal.	U.S.A., Col.	1890; Sargent, 1921 (67)	29, 66, 83, 95.	1
cultivated.	U.S.A., Col.	1915; Rehder, 1921 (66)	29, 83, 95.	2
(reduction division very irregular in *R. hispida* L.). Cultivated since 1920.	U.S.A., S.C.	Rehder, 1927 (66)	29, 50, 83.	3
also *R. dubia* Fouc., *R. intermedia* Soul.; cultivated.	U.S.A.	b. 1812; Rehder, 1927 (66)	29, 83.	4
F_2 produced; genetic study of leaves; cultivated since 1829.	Sweden	Heribert-Nilsson, 1918 (52) 1931	9, 26, 27, 28, 35, 36, 41, 66, 90.	1
F_2 produced; long cultivation in Europe; immune to button gall.	Europe; U.S.A.	Wichura, 1865 (110)	7, 9, 26, 28, 35, 66.	2
	Russia	Bogdanov, 1935 (10)	9, 26.	3
	U.S.A.?	Blackburn & Harrison, (9) 1924	26, 28, 35.	4
cultivated since 1900; $F_1n=21$–32.	N. Europe	Blackburn & Harrison, (9) 1924	26, 28, 35, 66.	5
cultivated since 1896; $F_1n=44$.	Europe	Rehder, 1927 (66)	9, 26, 28, 35.	6
cultivated since 1829.	Europe	Rehder, 1927 (66)	9, 26, 28, 35.	7
stipules of *S. americana* dominant; higher in tannin content than *S. americana*.	Germany	Wettstein, 1931 (88)	90.	8
stipules of *S. americana* dominant; vigor of *S. americana*.	Germany	Wettstein, 1931 (88)	9, 26.	9
stipules of *S. americana* dominant.	Germany	Wettstein, 1931 (88)	9, 26, 90.	10
cricketbat willow.		Schreiner, 1937 (73)	9, 26, 37.	11

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	***SALIX* L. WILLOW (Continued)**			
12	*S. nigra* Marsh. × *S. alba* L.	N	19 × 38	× *S. Hackensonii* Dode.
13	*S. pentandra* L. × *S. fragilis* L.	N	38 × 38	× *S. Meyeriana* Rostk.
14	*S. pentandra* L. × *S. alba* L.	N	38 × 38	× *S. Ehrhartiana* Sm.
15	*S. pentandra* L. × *S. purpurea* L.	N	38 × 19	× *S. heterandra* Dode.
16	*S. amygdalina* L. × *S. fragilis* L.	N	× 38	× *S. speciosa* Host.
17	*S. amygdalina* L. × *S. viminalis* L.	N	× 19	× *S. mollisima* Ehrh.
18	*S. fragilis* L. × *S. alba* L.	N	38 × 38	× *S. rubens* Schrank
19	*S. babylonica* L. × *S. alba* L.	N	× 38	× *S. sepulcralis* Simonk.
20	*S. babylonica* L. × *S. fragilis* L.	N	× 38	× *S. blanda* Anders.
21	*S. herbacea* L. × *S. formosa* Willd.	N		× *S. simulatrix* B. White.
22	*S. retusa* L. × *S. myrsinifolia* Salisb.	N		× *S. Cottetii* Lagger.
23	*S. caprea* L. × *S. myrsinifolia* Salisb.	N	19 (38) ×	× *S. latifolia* Forb.
24	*S. caprea* L. × *S. phylicifolia* L.	N	19 (38) × 44	× *S. laurina* Sm.
25	*S. aurita* L. × *S. cinerea* L.	N	38 × 38	× *S. multinerois* Doell.
26	*S. aurita* L. × *S. repens* L.	N	38 ×	× *S. ambigua* Ehrh.
27	*S. myrsinifolia* Salisb. × *S. hastata* L.	N		× *S. Mielichhoferi* Saut.
28	*S. phylicifolia* L. × *S. myrsinifolia* Salisb.	N	44 ×	× *S. tetrapla* Walker
29	*S. cordata* Muhlenb. × *S. sericea* Marsh.	N		× *S. myricoides* Muhlenb.
30	*S. daphnoides* Vill. × *S. caprea* L.	N	× 19 (38)	× *S. Erdingeri* Kern.
31	*S. lapponum* L. × *S. caprea* L.	N	× 19 (38)	× *S. Laestadiana* Hartm.
32	*S. viminalis* L. × *S. aurita* L.	N	38 × 38	× *S. fruticosa* Doell.
33	*S. viminalis* L. × *S. cinerea* L.	N	38 × 38	× *S. holosericea* Willd.
34	*S. incana* Schrank × *S. caprea* L.	N	× 19 (38)	× *S. Seringeana* Gaud.
35	*S. incana* Schrank × *S. aurita* L.	N	× 38	× *S. patula* Ser.
36	*S. incana* Schrank × *S. repens* L.	N	× 19	× *S. subalpina* Forb.
37	*S. incana* Schrank × *S. daphnoides*	N		× *S. Reuteri* Moritzi.
38	*S. purpurea* L. × *S. caprea* L.	N	19 × 19 (38)	× *S. Wimmeriana* Gren. & Godr.
39	*S. purpurea* L. × *S. grandifolia*	N	19 ×	× *S. austriaca* Host.
40	*S. purpurea* L. × (*S. aurita* L. × *S. phylicifolia* L.)	N	19 × (21-32)	× *S. sequitertia* B. White
41	*S. purpurea* L. × *S. cinerea* L.	N	19 × 38	× *S. Pontederana* Willd.
42	*S. purpurea* L. × *S. repens* L.	N	19 × 19	× *S. Doniana* Sm.
	***TAXUS* L. YEW**			
1	*T. cuspidata* Sieb. & Zucc. × *T. baccata* L.	N	12 ×	× *T. media* Rehd.
2	*T. cuspidata* Sieb. & Zucc. × *T. canadensis* Marsh.	N	12 ×	× *T. Hunnewelliana* Rehd.
	***TILIA* L. BASSWOOD, LINDEN**			
1	*T. cordata* Mill. × *T. platyphyllos* Scop.	N	36 × 40	× *T. vulgaris* Hayne
2	*T. americana* × *T. argentea*		× 40	
3	*T. platyphyllos* Scop. × *T. glabra* Vent.		40 ×	× *T. carlsruhensis* Simonk.
4	*T. cordata* Mill. × *T. dasystyla* Stev.	N	36 ×	× *T. euchlora* K. Koch.
5	*T. cordata* Mill. × *T. glabra* Vent.	N	36 ×	× *T. flavescens* A. Br.

Notes on hybrid	Country or region	Author and date of report or of origin	Other references	No.
		b. 1890; Rehder, 1927 (66)	9, 26.	12
cultivated in Europe, 1829.	Europe	Rehder, 1927 (66)	9, 26.	13
also *S. hexandra* (various authors); cultivated Europe, 1894.	Europe	Rehder, 1927 (66)	9, 26.	14
parentage not certain; cultivated in Caucasus since 1910.	Caucasus	Rehder, 1927 (66)	9, 26.	15
cultivated in Europe since 1821.	Europe	Rehder, 1927 (66)	9, 26.	16
cultivated in Europe, 1809.	Europe	Rehder, 1927 (66)	9, 26.	17
intermediate; very variable.		Rehder, 1927 (66)	9, 26.	18
more vigorous, less weeping than *S. bab.*		b. 1864; Rehder, 1927 (66)	9, 26.	19
weeping habit like *S. babylonica.*		b. 1830; Rehder, 1927 (66)	9, 26.	20
S. polaris Wahl. similar; cultivated since 1922.	Switzerland	Rehder, 1927 (66)		21
S. serpyllifolia Scop. a related var.; cultivated since 1905.	Europe (Alps)	Rehder, 1927 (66)		22
Harrison (36) found tetraploid *caprea;* cultivated since 1829.	Europe	Rehder, 1927 (66)	9, 26, 27, 36.	23
Harrison (36) found tetraploid *caprea;* cultivated since 1809.		Rehder, 1927 (66)	9, 26, 27, 36.	24
cultivated since 1873.	Europe	Rehder, 1927 (66)	9, 26	25
cultivated 1872.	Europe	Rehder, 1927 (66)	9, 26.	26
cultivated 1888.	Europe	Rehder, 1927 (66)		27
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	28
cultivated 1880.	U.S.A., Mass. to Wis., Kan.	Rehder, 1927 (66)		29
cultivated 1872.	Europe	Rehder, 1927 (66)	9, 26, 27, 36.	30
cultivated 1873.	Europe	Rehder, 1927 (66)	9, 26, 27, 36.	31
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	32
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	33
cultivated 1872.	Europe	Rehder, 1927 (66)	9, 26, 27, 36.	34
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	35
cultivated 1829.	Europe (Alps)	Rehder, 1927 (66)	9, 26.	36
cultivated 1870.	Europe	Rehder, 1927 (66)		37
cultivated 1872.	Europe	Rehder, 1927 (66)	9, 26, 27, 36.	38
cultivated 1870.	Europe	Rehder, 1927 (66)	9, 26.	39
cultivated 1900.	Europe	Rehder, 1927 (66)	9, 26.	40
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	41
cultivated 1829.	Europe	Rehder, 1927 (66)	9, 26.	42
intermediate; leaves similar to *T. cuspidata* but more distinctly 2-ranked.	U.S.A.	1900; Rehder, 1927 (66)	71.	1
resembles *T. cuspidata,* but of more slender habit and with narrower leaves.	U.S.A.	1900; Rehder, 1927 (66)	71.	2
fertile; occur mainly as planted trees.	U.S.A., Europe	Larsen, 1937 (52)	27, 29, 66, 86.	1
silver leaf of *argentea,* vigor of *amer.*	Russia	Kolesnikov, 1933 (48)	29, 86.	2
		Rehder, 1927 (66)	27, 29, 81, 86.	3
parentage doubtful.		Rehder, 1927 (66)	29, 86.	4
also × *T. Spaethii* Spaeth, and × *T. floribunda* A. Br.		Rehder, 1927 (66)	29, 86.	5

No.	Species involved	Nature of cross	Chromosome nos. (n) involved	Name of hybrid
	***TILIA* L.** BASSWOOD, LINDEN (Continued)			
6	*T. glabra* Vent. × *T. petiolaris* Hook.	N		× *T. Moltkei* Spaeth
7	*T. petiolaris* Hook. × *T. euchlora* K. Koch.	N		× *T. orbicularis* Jouin
8	*T. Miyabei* Jack. × *T. japonica* Simonk.			× *T. noziricola* Hisauti
	***TSUGA* CARR.** HEMLOCK			
1	*T. Mertensiana* Sarg. × *T. heterophylla* Sarg.	N		× *T. Jeffreyi* Henry
	***ULMUS* L.** ELM			
1	*U. glabra* Huds. × *U. foliacea* Gilib.	N		× *U. hollandica* Mill.
2	*U. campestris* × *U. effusa*	A	14 (+) ×	
3	*U. americana* × *U. laevis*	A	28 (14) × 14	
4	*U. montana* × *U. nitens*		14 ×	× *U. major* Smith
5	*U. glabra* × *U. montana*	N	× 14	Huntingdon elm
6	*U. glabra* Huds. × *U. pumila* L.	N	× 15	× *U. arbuscula* Wolf

Discussion

A detailed discussion of the data summarized in the above list will not be given, since it would require much space, and would probably be, at best, somewhat unwieldly and loosely connected. Furthermore, it is felt that the data as summarized hardly require such a discussion. Only a few general points, therefore, will be touched upon.

The above list includes many presumed hybrids which have been described by taxonomists on a purely morphological basis without definite experimental evidence as to parentage. Such presumed hybrids must be regarded with some caution, especially in genera in which experimental hybridization has not been done. On the other hand, it should be recognized that the description of these hybrids indicates that in the genera in question there must exist a considerable degree of integradation between species, which, in turn, indicates the probability that hybridization has occurred.

The author is aware that the value of including such hybrids is a debatable point. However, after some consideration it was decided to include hybrids of this class in instances where the assumed parentage appeared to be accepted generally as being reasonably certain. This action seemed best to serve one of the main objectives of the work—to indicate the species in a given genus, between which crossing is most likely to occur naturally or to be effected artificially.

Notes on hybrid	Country or region	Author and date of report or of origin		Other references	No.
cultivated since 1830.	Can. to N.C., west to Minn., Mo., U.S.A.	b. 1800; Rehder, 1927	(66)		6
	U.S.A.	1870; Rehder, 1927	(66)		7
	Japan	Hisauti, 1937	(42)		8
also *T. Mertensiana Jeffreyi* Schneid.; introduced U.S.A. 1851.	U.S.A.	Rehder, 1927	(66)		1
fertile; many named forms; tendency to be intermediate; vigorous growth; $F_1n=14$.	Europe, especially England; U.S.A.	Rehder, 1927	(66)	52, 54, 69.	1
more vigorous than parents.	Germany	Klotzsch, 1854	(52)	29, 49, 54, 85.	2
	U.S.A.	Sax, 1933	(69)	29, 49, 85.	3
× *U. serpentina* Henry, a pendulous var. of *U. major.*	England	Schreiner, 1937	(74)	29, 49, 54, 85.	4
very rapid growth (disc. by Rehder under No. 1).		Schreiner, 1937	(73)	29, 37, 49, 54, 85.	5
shrub habit of *U. pumila* dominant; cultivated	U.S.A.	1902; Rehder, 1927	(66)	85.	6

A number of named hybrids were not included because evidence as to parentage appeared to be lacking or of a very doubtful nature. These are as follows:

× *Acer hybridum* Spach. (74)
× *ramosum* Schwer. (*A. pseudoplatanus* L. × ?) (66)
× *rotundilobum* Schwerin (74)
× *sericeum* Schwer. (*A. pseudoplatanus* L. × ?) (66)
× *Crategus celsiana* Bosc. (*C. pentagyna* Waldst. & Kit. × ?) (66)
× *grignonensis* Mouillef. (*C. pubescens* Steud. × ?) (66)
× *persistens* Sarg. (possibly hybrid of *C. crus-galli* L.) (66)
× *sorbifolia* Lge. (*C. oxyacantha* L. × ?) (66)
× *Fraxinus elonza* Dippel. (74)
× *Larix Marschlinsii* (74)
× *Quercus demarei* Ashe (74)
× *dubia* Ashe (74)
× *Koehnii* (28, 94)
× *mallichampii* Trelease (67, 74)
× *podophylla* Trel. (74)
× *Salix renecia* Dode. (*S. cinerea* L. × ?) (66)

Attention is drawn to the fact that in *Quercus* there appears to be little or no crossing between the two sections of the genus, white oaks and black oaks

(Sargent's classification (67)). In the list, crosses 1 to 35, inclusive, and cross 77 involve only white oaks, while crosses 36 to 76, inclusive, involve only black oaks.

A similar condition exists in *Pinus*. Here all crosses except No. 13 involve hard (or pitch) pines exclusively. No. 13 involves two soft pines.

These points are important to the breeder, since they indicate possible limitations in intercrossability among certain groups of species in the genera in question. They also tend to give biological support to the taxonomists' division of these genera into sections.

On the other hand, in certain complex genera, *e.g.*, *Populus*, there appears to be little limitation to the crossing of species belonging to different sections—this information is, of course, very important to the breeder.

It is hoped that it will be possible within a few years to revise and extend the present work. To that end, the author would be greatly obliged to learn of omissions and inaccuracies in the present work, and to receive reprints of future publications on forest-tree hybridization for use in the proposed work.

Acknowledgments

The author gratefully acknowledges the valuable assistance of Dr. H. A. Senn on taxonomic problems, the excellent stenographic and general assistance of Mr. J. M. Gillett, and the kindness of Dr. C. Heimburger and Messrs. E. Druce and W. M. Robertson in reading the manuscript.

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EFFECTS OF PLANT AND ANIMAL HORMONES ON SEEDS DAMAGED BY FORMALDEHYDE[1]

By N. H. Grace[2]

Abstract

Marquis wheat was immersed in solutions of formaldehyde and formaldehyde containing either naphthylacetic acid or oestriol in concentrations of 0.1, 1, 5, and 10 p.p.m., and germinated on blotting paper or grown in soil at a temperature of from 70 to 75° F. A measure of physiological activity was shown by both chemicals from the results of germination on blotting paper; the activity of the two chemicals was of the same order. Growth in soil failed to show anything but injurious effects from formaldehyde.

In another experiment, Marquis wheat was sprinkled with solutions of formaldehyde and indolylacetic acid and grown in soil at a temperature of from 50 to 55° F. The sprinkling treatment, which supplied one part of indolylacetic acid to a million parts of wheat by weight, reduced formaldehyde injury in a statistically significant manner. Lower concentrations of the chemical did not reduce injury to a significant extent.

A recent publication described the results of experiments in which plant cuttings were treated with dusts and solutions containing oestrone and indolylbutyric acid (3). In view of the results from the treatment of plant cuttings, it was of interest to consider other methods of determining the physiological activity of oestrogenic substances. It has been shown that a number of chemicals reduce seed injury arising from disinfection with formaldehyde solutions and other similar treatments (2). In consequence, this method was chosen in an effort to determine the activity of an oestrogenic hormone, oestriol, and incidentally, to investigate further the effects of indolylacetic and naphthylacetic acids on formaldehyde injury.

Experimental

Solutions were prepared by dissolving 0.05 gm. of each of the chemicals in 1 cc. of 95% alcohol and diluting with formaldehyde solution to give 50 p.p.m. (parts per million) in 1 : 320 formaldehyde. Subsequent dilution with formaldehyde of the same concentration permitted ready preparation of the various concentrations required.

In the first experiment, 50-gm. samples of Marquis wheat were immersed in 50 cc. of a 1 : 320 solution of formaldehyde* (37% by weight of the gas) for 5 min. (2). The samples were drained for 2 min., placed on filter paper and covered with inverted cans for 4 hr. Each sample was then loosely wrapped in small pieces of canvas to prevent aeration and planted approximately 24 hr. after treatment.

* *Polymer-free formaldehyde specially prepared by the Standard Chemical Company, Montreal.*

[1] *Manuscript received September 15, 1939.*

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The series of treatments included untreated and formaldehyde-treated controls and concentrations of 0.1, 1, 5, and 10 p.p.m. of each of the chemicals separately in formaldehyde, making 10 treatments in all. Eight replicates of 50 seeds were planted on blotting paper in a germinator maintained at a temperature of approximately 65° F. Ten replicates of 50 seeds were planted in small cardboard flats and kept in a greenhouse at a temperature of approximately 72° F. Germination counts were made five and nine days after planting on blotting paper; the number of seminal roots was counted and length of each stem measured from the seed to the tip of the longest leaf, and expressed as number of roots and length of stem per seedling. Germination rates computed by Bartlett's method (1), final germination, and air-dry weights of tops and roots for the plants from 50 seeds, were determined from the plants grown in soil. The plants were washed out of soil 23 days after planting, placed in an oven at 95° for two hours, and conditioned for one week in the laboratory.

The second experiment involved the use of five treatments comprising untreated and formaldehyde controls and 0.1, 1, and 5 p.p.m. of indolylacetic acid in formaldehyde solution. Twenty-five-gram samples of Marquis wheat were sprinkled with 5 cc. of the 1 : 320 commercial formaldehyde (37% by weight of the gas) solutions. Sprinkling with solutions of the concentrations mentioned gave seed treatments with 0.02, 0.2, and 1 parts of indolylacetic acid per million parts of seed by weight. The samples of treated seed were covered with inverted cans for four hours and then wrapped in canvas overnight. Ten replicates of 50 seeds of each of the five treatments were planted in soil in small cardboard flats, approximately 24 hr. after treatment, and held in a greenhouse at a temperature between 50 and 55° F. The experiment was arranged in the form of two contiguously placed Latin squares each containing five replicates of the five treatments. Germination rates, final counts, and air-dry top and root weights 36 days after planting, were determined in the manner already described.

TABLE I

ANALYSIS OF VARIANCE OF RESPONSE OF MARQUIS WHEAT TREATED WITH SOLUTIONS OF OESTRIOL AND NAPHTHYLACETIC ACID IN FORMALDEHYDE AND GERMINATED ON BLOTTING PAPER

Source of variance	Degrees of freedom	Mean square			
		Germination at		Per seedling	
		Five days	Nine days	Number of seminal roots	Stem length
Replicates	7	304.5***	65.3***	0.09997	377.67***
Treatments	9	150.5***	26.8**	0.62970***	381.82***
Error	63	18.5	8.7	0.08181	73.89

** *Exceeds mean square error, 1% level of significance.*

*** *Exceeds mean square error, 0.1% level of significance.*

TABLE II

EFFECTS OF FORMALDEHYDE–HORMONE TREATMENTS ON THE RESPONSES OF MARQUIS WHEAT GERMINATED ON BLOTTING PAPER

—	Controls		Formaldehyde and naphthylacetic acid, p.p.m.				Mean of all treatments with naphthylacetic acid	Formaldehyde and oestriol, p.p.m.				Mean of all treatments with oestriol	Necessary differences, 5% level
	Untreated	Formaldehyde	0.1	1	5	10		0.1	1	5	10		
Germination at 5 days[4]	38.1	21.6	30.0	27.4	33.2	30.9	30.4	28.8	30.0	31.0	26.4	29.0	4.3[1] 3.4[2] 2.1[3]
Germination at 9 days[4]	43.0	41.3	46.4	43.5	46.9	45.6	45.5	44.8	45.9	46.8	44.4	45.5	2.9[1] 2.3[2] 1.5[3]
Number of seminal roots per seedling	3.50	4.18	4.41	4.08	4.31	4.42	4.31	4.39	4.43	4.18	4.24	4.31	0.29[1] 0.23[2] 0.14[3]
Length of stem per seedling, mm.	100.5	76.9	79.1	80.0	84.5	85.3	82.2	87.5	83.6	81.8	77.0	82.5	8.8[1] 6.8[2] 4.3[3]

[1] *Necessary difference between individual treatments.*
[2] *Necessary difference between formaldehyde control and means.*
[3] *Necessary difference between means of treatments with naphthylacetic acid and oestriol.*
[4] *Number of seeds germinated of 50 planted.*

Results

Formaldehyde–hormone Treatment of Marquis Wheat

Results from Growth in the Germinator on Blotting Paper

In Table I are given results for the analyses of variance, and in Table II, treatment means for the data on germination at five and nine days, and the number of seminal roots and stem lengths per seedling for wheat germinated on blotting paper. Treatment effects were significant for each of the four sets of observations. Germination counts at five days demonstrated significant injury from formaldehyde treatment and reduction of injury with each of the treatments with plant and animal hormones, the difference between the means for all naphthylacetic acid and oestriol treatments was not significant. While the final nine-day germination count failed to show significant reduction on treatment with formaldehyde alone, all the treatments gave greater germination than was shown by the formaldehyde control. Germination means for each of the four treatments are greater than the value for formaldehyde, but no significant difference is shown between naphthylacetic acid and oestriol. None of the hormone treatments differed from the formaldehyde treatment, which effected a significant increase in the number of seminal roots per seedling. Furthermore, a marked reduction in stem length was caused by formaldehyde treatment. Treatment with 0.1 p.p.m. oestriol in formaldehyde significantly increased stem length; none of the other treatments differed from formaldehyde alone.

Results from Growth in Soil

The analyses of variance and treatment means for germination rates, final germination count, and air-dry top and root weights are given in Tables III and IV. Treatment effects were highly significant for each of the four characters considered; however, significance was related to the depressing effects of formaldehyde treatment. The effect of 10 p.p.m. oestriol in formaldehyde on both top and root weights approached a significant reduction in injury.

TABLE III

Analysis of variance of response of Marquis wheat treated with solutions of oestriol and naphthylacetic acid in formaldehyde and grown in soil

Source of variance	Degrees of freedom	Mean square			
		Germination		Air-dry weight	
		Rates	Final count	Tops	Roots
Replicates	9	0.05134***	130.58***	0.03506**	0.00378**
Treatments	9	0.04804***	194.12***	0.08194***	0.01281***
Error	81	0.00268	28.03	0.01000	0.00106

** *Exceeds mean square error, 1% level of significance.*
*** *Exceeds mean square error, 0.1% level of significance.*

TABLE IV

EFFECTS OF FORMALDEHYDE–HORMONE TREATMENTS ON THE RESPONSES OF MARQUIS WHEAT GROWN IN SOIL

—	Controls		Formaldehyde and naphthylacetic acid, p.p.m.				Mean of all treatments with naphthylacetic acid	Formaldehyde and oestriol, p.p.m.				Mean of all treatments with oestriol	Necessary differences, 5% level
	Untreated	Formaldehyde	0.1	1	5	10		0.1	1	5	10		
Germination rates	0.857	0.657	0.662	0.648	0.648	0.637	0.649	0.633	0.617	0.625	0 672	0.637	0.046[1] 0.036[2] 0.023[3]
Final germination from 50 seeds	46.7	32.5	34.4	31.6	33.3	31.4	32.7	35.1	34.2	33.4	35.9	34.7	4.7[1] 3.7[2] 2.4[3]
Air-dry weight of tops from 50 seeds, gm.	0.909	0.610	0.654	0.582	0.629	0.628	0.623	0.660	0.645	0.658	0.698	0.665	0.089[1] 0.070[2] 0.044[3]
Air-dry weight of roots from 50 seeds, gm.	0.253	0.137	0.157	0.140	0.145	0.140	0.146	0.148	0.147	0.126	0.165	0.147	0.029[1] 0.023[2] 0.014[3]

[1] *Necessary difference between individual treatments.*
[2] *Necessary difference between formaldehyde control and means.*
[3] *Necessary difference between means of treatments with naphthylacetic acid and oestriol.*

While oestriol treatment gave a greater weight of tops than naphthylacetic acid treatment, the difference is just insufficient for significance. Apart from these suggestions of possible effects from hormone treatment, the only clearly demonstrated effect was injury from treatment with formaldehyde alone.

Formaldehyde–indolylacetic Acid Treatment of Marquis Wheat

The results secured from analysis of variance and the effects of treatments on germination rates, final germination counts, and air-dry weights of tops and roots, for plants grown in soil, are given in Tables V and VI. Formaldehyde treatment effected significant reduction in each case. Treatment with 5 p.p.m. indolylacetic acid solution (or 1 p.p.m. of the weight of the seed)

TABLE V

Analysis of variance of response of Marquis wheat treated with solutions of formaldehyde and indolylacetic acid

Source of variance	Degrees of freedom	Mean square			
		Final germination count	Germination rate ($\times 10^4$)	Air-dry weight	
				Tops ($\times 10^3$)	Roots ($\times 10^3$)
Squares	1	32.00*	0.72	203.64***	140.45***
Rows	8	2.34	28.91	18.58*	9.09
Columns	8	4.64	21.86	12.56	8.80
Treatments	4	31.33**	512.80***	69.17***	59.69***
Treatments × squares	4	7.65	22.45	3.29	5.84
Error	24	5.72	13.42	7.59	6.02

* *Exceeds mean square error, 5% level of significance.*
** *Exceeds mean square error, 1% level of significance.*
*** *Exceeds mean square error, 0.1% level of significance.*

TABLE VI

Effects of formaldehyde–indolylacetic acid treatments on the responses of Marquis wheat grown in soil

—	Controls		Concentration of indolylacetic acid in 1 : 320 formaldehyde, p.p.m.			Necessary difference, 5% level
	Untreated	Formaldehyde	0.1	1	5	
Germination[1]	46.2	41.5	42.8	42.5	43.2	2.2
Germination rates	0.767	0.592	0.611	0.606	0.627	0.034
Air-dry weight of plants from 50 seeds, gm.						
Tops	1.20	0.98	1.04	1.04	1.09	0.08
Roots	0.63	0.46	0.48	0.44	0.49	0.07

[1] *Number of seeds germinated of 50 planted.*

significantly increased the germination rate and the air-dry weight of tops from 50 seeds, as compared with the formaldehyde control, but did not increase root weights or the final germination to a significant extent. The lower indolylacetic acid concentrations failed to give any significant effects.

Discussion

Marquis wheat treated with solutions of formaldehyde and formaldehyde naphthylacetic acid or oestriol, and germinated on blotting paper, indicated a measure of physiological activity for both chemicals. However, there were no significant differences between the means for all concentrations of each chemical, and the results indicated that oestriol reduced formaldehyde injury to about the same extent as naphthylacetic acid. The results from growth in soil failed to show any reduction in formaldehyde injury from either naphthylacetic acid or oestriol.

The results of germination (9-day counts) on blotting paper indicated that even though formaldehyde treatment failed to reduce germination significantly, highly significant effects were shown by the decrease in length of the stem and increase in the number of seminal roots per seedling. Effects of formaldehyde injury were more marked on plants grown in soil.

In the second experiment, when Marquis wheat was sprinkled, a treatment of 1 p.p.m. of indolylacetic acid reduced injury in a statistically significant manner, but 0.02 or 0.2 p.p.m. of the hormone was inadequate. This result is in general agreement with earlier work on plants grown in soil (2). The positive effects from formaldehyde–indolylacetic acid treatment on plants grown in soil may have been due to differences in effectiveness of this chemical and naphthylacetic acid, or to the different temperatures under which growth occurred.

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EFFECT OF VARIOUS CONDITIONS OF STORAGE ON BAKING QUALITY OF FLOUR[1]

By A. G. McCalla[2], J. D. McCaig[3], and A. D. Paul[4]

Abstract

Flour stored in sealers in a refrigerator at 2° C. did not change in quality for 22 months after milling. Similar flours stored in sealers at room temperature deteriorated significantly within three months, while a third lot stored in small bags at room temperature showed first a definite improvement and then rapid deterioration. At the end of 22 months flours stored in sacks were much the poorest. Acidity of all flours increased with storage, but this determination was of little value in estimating flour quality.

Introduction

Routine tests carried out at this institution showed that flours varied in keeping properties during storage, depending on the storage conditions and on the variety and source of wheat from which they were milled (1, 7). Flours stored for 12 months in air-tight sealers maintained their quality better than did flours stored in small sacks, despite the fact that the latter contained much less moisture than the former. In general, flours milled from wheats grown on the black loam at Edmonton maintained their quality better than flours milled from the same varieties of wheat grown on the grey podsolic loam typical of much of western and northern Alberta.

Studies on flour storage in general show that under ideal conditions of packaging, temperature, humidity, etc., high grade flour will maintain its quality for many months, and even years (3, 5–8). Under less favourable conditions, however, deterioration may be marked in a few months.

The most comprehensive recent study has been carried out by Fisher *et al.* (5). They found a periodicity in improvement and deterioration of quality, and in various chemical properties. In general, however, the results with respect to keeping properties as affected by storage conditions and nature of flours confirm those obtained in earlier work. No definite "best" conditions of storage can be determined as a result of past experience under experimental conditions.

The work here reported was carried out with the object of checking previous results, and of following more closely the changes in flour quality with storage.

[1] *Manuscript received July 14, 1939.*

Contribution from the Department of Field Crops, University of Alberta, with financial assistance from the National Research Council of Canada. Published as Paper No. 168 of the Associate Committee on Grain Research of the National Research Council and Dominion Department of Agriculture.

[2 3 4] *Research Assistant, Graduate Assistant, and Technician, respectively, Associate Committee on Grain Research, University of Alberta, Edmonton.*

Material and Methods

Four varieties of wheat; Garnet, Marquis, Red Bobs, and Reward, each grown in 1936 at Edmonton and Fallis (50 miles west of Edmonton) were milled on an experimental mill to produce long patent flours. The data pertinent to this study are given in Table I. All samples were sound and well matured, those from Fallis being unusually high in protein because the growing season was very dry. In average seasons, the protein content of these varieties of wheat would be 2 to 3% lower than in 1936.

TABLE I

DATA PERTAINING TO ORIGINAL QUALITY OF WHEATS USED IN STUDY

Station	Type of soil	Variety	Weight, per bushel, lb.	Commercial grade	Protein, %	Loaf volume, cc.
Edmonton	Black loam	Garnet	65.0	1 C.W. Gar.	14.1	325
		Marquis	65.5	2 Nor.	15.0	373
		Red Bobs	64.0	1 Nor.	14.3	378
		Reward	65.0	1 Nor.	16.5	448
Fallis	Podsolic loam	Garnet	65.5	1 C.W. Gar.	12.5	263
		Marquis	65.0	3 Nor.	12.3	283
		Red Bobs	65.0	2 Nor.	12.0	300
		Reward	67.0	2 Nor.	14.7	393

The flour was stored in large cans for one month after milling. This is the regular practice in this laboratory, chiefly because the experimental milling and baking are done by the same man. It has also been found that most flours stored for one month before baking produce decidedly better bread than if baked immediately after milling. Baking tests were then made, and each sample of flour was divided into three lots. The conditions of storage were as follows:

Lot 1: Stored in glass sealers which were kept in a refrigerator at 2° C. The sealers were removed only to permit sampling.

Lot 2: Stored in sealers on open shelves in the laboratory. Temperature varied between 16 and 28° C. at different times of the year.

Lot 3: Stored in small cotton sacks in the same room as Lot 2.

The flour contained approximately 13.5% moisture at the beginning of the experiment. At the end of 22 months the moisture content of the three lots was approximately 13.5, 11.0, and 8.0%.

All baking tests were carried out using 50 grams of flour and the malt-phosphate-bromate formula (2).

Acidity was determined by the Greek method (4), using tincture of curcuma as indicator. Results are reported as the volume of $N/50$ sodium hydroxide required to neutralize 10 cc. of the alcoholic extract.

TABLE II

LOAF VOLUME OF BREAD BAKED FROM FLOUR STORED UNDER VARIOUS CONDITIONS

Station	Variety	Original volume, July 1937	Condition of storage								
			Sealers at 2° C.			Sealers at room temperature			Sacks at room temperature		
			December 1937	July 1938	April 1939	December 1937	July 1938	April 1939	December 1937	July 1938	April 1939
Edmonton	Garnet	325	300	258	284	260	220	250	379	270	162
	Marquis	373	358	393	337	353	344	334	445	279	217
	Red Bobs	378	418	426	420	369	373	362	473	344	240
	Reward	448	465	386	430	408	376	365	485	342	251
	Mean	381	385	366	368	348	328	328	446	309	218
Fallis	Garnet	263	280	253	302	260	215	237	300	210	140
	Marquis	283	320	300	275	290	273	275	344	243	172
	Red Bobs	300	337	315	320	300	288	293	351	290	175
	Reward	393	408	437	392	367	310	327	457	313	165
	Mean	310	336	326	322	304	272	283	363	264	163

Results

Baking tests were carried out 1, 4, 6, 9, 13, 18, and 22 months after the flours were milled. Results for loaf volume of individual samples at 1, 6, 13, and 22 months are given in Table II, and the results of analyses of variance for all data in Table III.

TABLE III

Analysis of variance, loaf volume of bread stored under three sets of conditions

Variance due to	D.f.	Mean squares		
		Sealers at 2° C.	Sealers at room temperature	Sacks at room temperature
Station	1	46,980*	38,587*	72,216**
Variety	3	44,963*	35,233*	24,343**
Time of storage	6	622	2,652**	50,486**
Station × Variety	3	3,332	1,775**	671
Station × Time	6	366	411	1,316*
Variety × Time	18	405	338	579
Station × Variety × Time	18	2,823	184	387
Total	55			

* *Significant beyond the 5% point.*
** *Significant beyond the 1% point.*

The effects of station and variety were significant for all conditions of storage These effects were largely the result of differences in protein content of the wheat from which the flour was milled, although the Garnet samples fell somewhat below the general protein-loaf-volume level. Contrary to expectations from the results of earlier studies (1, 7), there was no significant interaction between variety and station, except in the case of flour stored in sealers. Even with this flour the magnitude of the interaction was small, though significant, and attributable chiefly to the behaviour of one variety, Red Bobs.

The effect of time of storage was very different with the three conditions of storage.

Since there were virtually no significant interactions, one graph drawn from the means for the four varieties and two stations presents the important results obtained in the study. This is given in Fig. 1. The slight increase in mean loaf volume for the flours stored in the refrigerator is not significant, but the decrease in volume for the flours stored in sealers on open shelves is. The flour stored in sacks shows what has been considered as a normal course in aging, that is, first an improvement, and then a sharp decrease, in quality (3).

The results of earlier studies showed that acidity of all flours increased with age, but that the increases were not parallel to changes in quality. Acidity determinations were made 1, 6, 13, and 22 months after milling. The results are presented in Table IV and Fig. 2. The results of analyses of variance

TABLE IV

ACIDITIES OF FLOUR (CC. OF $N/50$ SODIUM HYDROXIDE) STORED UNDER VARIOUS CONDITIONS

Station	Variety	Original, July 1937	Condition of storage								
			Sealers at 2° C.			Sealers at room temperature			Sacks at room temperature		
			December 1937	July 1938	April 1939	December 1937	July 1938	April 1939	December 1937	July 1938	April 1939
Edmonton	Garnet	1.25	1.71	1.68	1.96	2.00	2.07	2.50	1.57	2.07	2.43
	Marquis	1.07	1.46	1.54	1.57	1.43	2.11	1.79	1.39	1.50	1.71
	Red Bobs	1.11	1.61	1.79	1.50	2.07	1.79	1.79	1.46	1.86	2.03
	Reward	1.18	1.43	1.68	1.57	1.57	1.86	1.96	1.50	1.79	2.06
	Mean	1.15	1.55	1.67	1.65	1.77	1.96	2.01	1.65	1.81	2.06
Fallis	Garnet	1.14	1.61	1.61	1.50	1.64	1.79	2.07	1.68	1.86	1.86
	Marquis	1.36	1.64	1.86	2.00	2.14	2.25	2.64	1.86	2.14	2.21
	Red Bobs	1.36	1.57	1.57	1.61	1.79	2.11	1.96	1.43	2.18	1.93
	Reward	1.11	1.61	1.57	1.61	1.75	1.93	2.07	1.75	2.07	1.71
	Mean	1.24	1.61	1.65	1.68	1.83	2.02	2.06	1.68	2.20	1.93

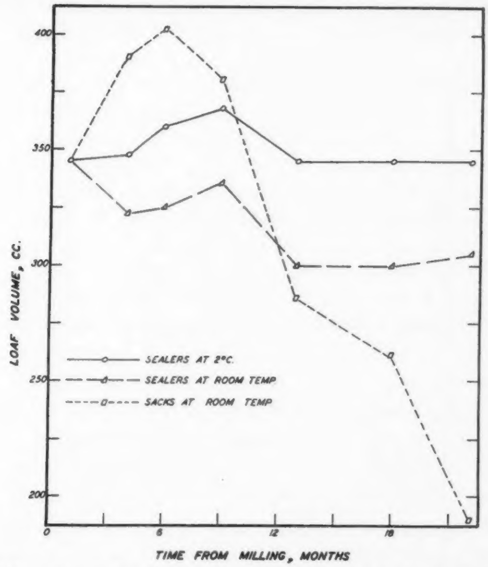

FIG. 1. *Effect of method and time of storage of flour on the loaf volume of bread.*

of these data are given in Table V. These results are in striking contrast with the loaf volume results, since time had a very marked effect on acidity of all samples. The significant interaction between station and variety is largely attributable to the behaviour of Garnet and Marquis, the Edmonton-grown

TABLE V

ANALYSIS OF VARIANCE, ACIDITY

Variance due to	D.f.	Mean squares		
		Sealers at 2° C.	Sealers at room temperature	Sacks at room temperature
Station	1	0.0121	0.0925	0.0365
Variety	3	0.0149	0.0348	0.0291
Time	3	0.3968**	1.3026**	1.0794*[a]
Station × Variety	3	0.0813*	0.2095*	0.1553**
Station × Time	3	0.0042	0.0038	0.0754*
Variety × Time	9	0.0073	0.0287	0.0095
Station × Variety × Time	9	0.0156	0.0362	0.0192
Total	31			

* *Significant beyond 5% point.*
** *Significant beyond 1% point.*
[a] *Station × Time as error.*

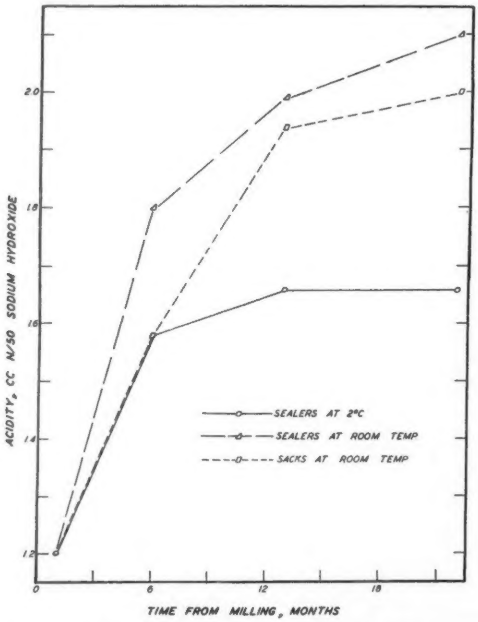

FIG. 2. *Effect of method and time of storage of flour on acidity.*

sample of the former being very high in acidity, while the acidity of Fallis-grown Marquis was higher than that of any of the other varieties, regardless of conditions of storage.

The differences due to station and variety were not significant under any condition of storage. The results with flours stored in the refrigerator are of interest because they show that after the first few months of storage, there was very little increase in acidity during the next 15 months.

Discussion

The results presented in this paper substantiate conclusions drawn from earlier work with respect to the effect of various conditions of storage on the keeping properties of flours, but fail to substantiate those concerned with the differential behaviour of flours from different varieties of wheat and different sources. The results of the earlier work showed that some varieties produced flour that deteriorated much faster than that from other varieties, and that wheat grown on the podsolic loam produced flour of much poorer keeping properties than did wheat grown on the black loam (7). The failure to confirm these results may be due to the higher than usual protein content of the wheat grown on the podsolic loam, but is more likely the result of some other factor

associated with the very dry growing conditions under which the wheat was produced.

From the practical point of view the results show that flour stored at low temperatures maintains its original quality for long periods, even though the moisture content does not decrease with time. Storage in sacks, the most common method used commercially, is the least effective in preserving quality. Under conditions used in commercial storage, however, the changes which take place in the sacked flour would be much slower than under our conditions. Even under these conditions the quality of the flour was as good as, or better than, it was at the time of milling for at least nine months thereafter. During the interval, this flour made better bread than that stored under either of the other sets of conditions. The original improvement shown by this flour is characteristic of stored flour in general.

The acidity results show that this determination is of very little value in determining either quality, or degree of aging, of flour. These conclusions are in agreement with those reported earlier (7).

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STUDIES IN TREE PHYSIOLOGY

I. GENERAL INTRODUCTION. WATER CONTENTS OF CERTAIN CANADIAN TREES[1]

By R. Darnley Gibbs[2]

Abstract

Previous work by the author on the water contents of Canadian trees is reviewed and followed by a brief discussion of questions yet to be answered.

In *Betula alba v. papyrifera*, in at least the young parts of *B. alba v. pendula laciniata*, in *B. populifolia*, and in several sizes of *Populus tremuloides*, there is a marked seasonal rhythm in water content. The maximum is at leaf opening, the minimum at leaf fall. In poplar but not in birch there is a very high water content in December. During winter a considerable loss of water may occur. A winter loss is shown also by the wood of hemlock and larch and by twigs and leaves of white pine and hemlock. Losses from leaves are surprisingly small.

The behaviour of *B. populifolia* has been studied for more than three years, and differences have been correlated with observations on weather conditions. Experimental work on movement of water in this species during winter is inconclusive. This work continues.

General Introduction

It is estimated that of Canada's 3,457,247 square miles of land, 1,254,083 square miles, or 36.2%, are covered by forest. Not all of this is productive, but the Department of the Interior (2) believes that more than 800,000 square miles have "merchantable" forest; further classification into forest types is still incomplete.

Extensive data dealing with wastage from fire and other causes and with annual increment and cut are available, as might be expected when the value of these natural resources is taken into consideration. Forest pathology, entomology, and genetics (as in the breeding of new fast-growing trees) are coming to the fore and it is, perhaps, true to say that the woods are beginning to receive their due share of scientific attention. Very little is known, however, of the *normal physiology* of Canadian trees, and almost any information on this subject contributes in some measure to an understanding of the problems involved in the efficient utilization of trees.

It is well known that the effects of fungal and insect pests and of difficult climatic and soil conditions upon trees vary in large part with the health of the tree. A full knowledge of the behaviour of the normal tree is therefore necessary to an intelligent study of the "diseased" individual. This is equally true whether the troubles be due to water or salt deficiencies (or excesses), to fungal or insect predators, or to excessive cold.

[1] *Manuscript received April 12, 1939.*

Contribution from the Department of Botany, McGill University, Montreal, Canada, with financial assistance from the National Research Council of Canada.

[2] *Assistant Professor of Botany, McGill University.*

The writer's introduction to tree physiology was occasioned about 10 years ago by a request from the Canadian Pulp and Paper Association for information on the seasonal changes in water content of trees. This was needed in connection with efforts to limit the loss of logs by sinkage during flotation. A certain amount of work had been done in Europe by Hartig (12–14), Tonkel (see Büsgen (1)), Geleznow (4), and Craib (3), but the figures were incomplete and it was doubtful if they could be applied safely to Canadian trees. With grants from the Association and from the National Research Council, many water-content determinations were made and the results published in a series of papers (5–9, 11, 16). The trees investigated included paper birch (*Betula alba* var. *papyrifera* (Marsh.) Spach.), aspen poplar (*Populus tremuloides* Michx.), jack pine (*Pinus banksiana* Lamb), white spruce (*Picea canadensis* (Mill.) P.S.P.), larch (*Larix laricina* (Du Roi) Koch), and balsam fir (*Abies balsamea* (L) Mill.). The data, though extensive, were incomplete. They were adequate, however, to reveal the following facts.

a. In the case of paper birch and poplar there is a spring maximum of water content when the trees are practically full of water. This coincides with the swelling and breaking of the buds.

b. Following leaf opening there is a rapid decrease in water content, which continues until August or September. This reduces the amount of water in the tree to little more than half the spring value.

c. After leaf fall the water content rises. The increase is rapid in poplar and proceeds until, at about the end of the year, the tree is again practically full of water. In birch, on the other hand, the increase is much smaller and the tree fills only partially with water during the autumn (7, Figs. 4 and 8).

d. There was some slight indication of a *decrease* in water content during the depth of winter. Few figures were obtained from this period, however, so little definite information as to amount of winter-drying could be given.

e. The *distribution* of water in birch and poplar is consistent with the tension hypothesis of the ascent of sap. This is supported by values for borings at different heights in the tree (8, Table I). Further support is given by the water contents at different heights of individual year-rings in birch, poplar, larch, and spruce (8, Fig. 1).

f. In the softwoods examined (jack pine, white spruce, balsam fir) there is little evidence of seasonal change (7, Tables V–VII).

g. The heartwoods of jack pine and spruce are consistently dry, having practically no *free* water at any time. The heartwood of balsam fir, on the other hand, contains wet patches which may contain more water than the sapwood.

h. Girdling, as a means of reducing water content, is effective only if a complete ring of sapwood be removed. This is not possible in the case of birch and poplar. In the first the whole wood is functional: in the second the sapwood is so wide that all except the very largest of girdled trees would be unstable. Large spruce and balsam may be girdled with success. The wet

patches of the heartwood in girdled balsam, however, do not dry out (at least not in a single season). It was concluded from this that they do not function as water reservoirs. Further investigation of these patches is planned.

i. Superimposed upon the seasonal rhythm is a daily fluctuation, at least in summer (7, pp. 744–6). This fluctuation appears to be relatively small. It is not known for certain whether there is any replacement of broken water columns during these diurnal cycles, but probably only enough water to relieve tension enters the plant during each period of reduced transpiration. Diurnal cycles in diametral changes in trees are well known and have recently been discussed in detail by MacDougal (15). Very little has been done to correlate these with changes in water content, however, though they are no doubt very closely correlated.

j. The behaviour of the tree may vary considerably from year to year (7, Fig. 4).

Enough has been said to show that while the major changes in water content of a few Canadian trees are now fairly well known, there are many points that require further investigation and still others that have not received attention at all. A brief discussion of some of these is in order.

a. Do hardwoods other than paper birch and aspen poplar show a similar seasonal rhythm? May we assume that *all* hardwoods are alike in the general pattern of their behaviour? Are the differences between paper birch and aspen poplar *generic*, *i.e.*, do all species of poplar fill completely with water in the fall and do all species of birch fill only partially during the same period?

b. Do all softwoods behave like those mentioned above or are some like the hardwoods in their behaviour? Larch, with its deciduous habit, should be a particularly interesting tree in this respect.

c. What is the extreme range in behaviour of a single type under varying conditions? This is obviously of the greatest interest for an understanding of "test" years of drought and of extreme cold, for example. It should contribute, too, to our knowledge of the factors determining the climatic and geographic ranges of species. It can help us to distinguish between "abnormal" behaviour, which is due to disease or damage, and the "normal" reaction of the tree to weather and other conditions. When injury *does* occur it may help us to fix the blame and to guard against future damage.

d. How complete is winter rest? Is there any movement of water into and through the tree during the winter? Some investigators seem to believe that there is. The question can be settled without serious difficulty. How much water is lost from the exposed parts of trees during winter? Is this (under Quebec conditions) ever dangerously great? Is there any actual shortage of water in summer, *i.e.*, will irrigated trees behave like those receiving no artificial supply? These questions will be answered if Question *c* be answered.

e. In the case of trees such as aspen poplar and balsam fir, which contain a varying amount of free water in the heartwood, is there *at any time* a utiliza-

tion of that water? One is tempted to conclude from work already carried out that the answer to this question is a flat negative, but the fact is that our information is still too incomplete to warrant such a sweeping assertion. It is relevant to note, in this connection, that in trees such as jack pine and white spruce, which have no free water in the heartwood, the water must have been removed in the transition from sapwood to heartwood.

f. Do young and old trees of the same species behave similarly?

g. So far only the water economy of the tree has been considered. What of other aspects of tree physiology? What foodstuffs are stored and what seasonal changes in these occur? A tremendous amount of work has been carried out elsewhere on a great variety of trees, but many points are still unsettled and there is much to be done before we shall have anything like a complete picture of the behaviour of Canadian trees.

In this and in subsequent papers of this series (one of which is in course of preparation) it is hoped to answer a few of the questions posed above. It is hardly necessary to point out the practical interest of such information, for almost any fact about tree physiology is likely to have a practical value.

Water Contents of Certain Canadian Trees

Introduction

The work reported in the present paper deals with determinations of water contents. Some of these make more complete the record for trees already studied; others extend investigation to new species. Most observations deal with the wood, but some few apply also to buds and to leaves. As in previous work, oven-drying at 100 to 105° C. has been used, and figures are expressed as a percentage based on dry weight. In all cases weighing of freshly cut pieces was carried out in the field, or samples were placed in weighed, rubber-stoppered vials and weighed on return to the laboratory. It was felt that considerable error might result from oven-drying of coniferous woods and leaves and this has been checked by tetrachloroethylene distillation (10). Except in one or two cases, which are mentioned below, the errors involved were found to be negligible.

1. Paper Birch (*Betula alba* var. *papyrifera* (Marsh.) Spach.)

Figures previously reported (7) for this tree are incomplete, one of the worst gaps in the record occurring in the period of winter "rest". With a view to filling this gap, a number of determinations were made in the spring of 1937 on trees cut on the Price Bros. limits, 40 miles north of Chicoutimi and from the same stand as those used in 1929–31 (7).

The results are given, together with the earlier ones, in Figs. 1 and 5 and in Table VI.

It is clear that there is a distinct, but not large, loss of water from paper birch between December and April and that this is most marked in the upper, smaller parts of the tree. The figures obtained on May 20, 1937, are

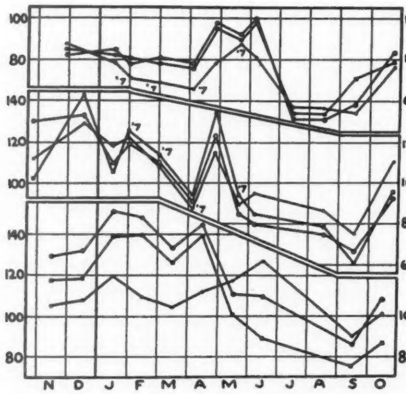

FIG. 1. *Water contents of paper birch (top) and aspen poplar (middle) from the Price Bros. limits and of aspen poplar (bottom) from Ste. Anne de Bellevue. Results are for discs from "tops" (dots), "middles" (circles), and "butts" (squares). Figures obtained in 1937 are indicated by '7. The curves for aspen poplar from Ste. Anne de Bellevue are averages for three sizes of tree (Table I).*

at first sight most surprising, the average values (six trees) for "top", "middle", and "butt" being 89, 92, and 91%. When these were taken small patches of snow still remained in sheltered places, but the buds were just opening and four of the six trees bled profusely. Evidently these trees were not by any means full of water (they can hold 135% at saturation) although cut at just the time when saturation would be expected. It is almost certain that this indicates a condition like that shown by field birch at Ste. Anne de Bellevue in the same year (see below and Fig. 3), an extremely interesting point and one that should be checked by further work.

2. WHITE BIRCH VARIETY (*Betula alba* var. *pendula laciniata*?)

Analyses of buds, ultimate twigs and penultimate twigs from a single isolated specimen of this ornamental birch growing on the McGill campus were made between December 1935 and November 1936 (Fig. 2). The analyses of penultimate twigs are for wood only and so are directly comparable with those for "tops" of paper birch and field birch. In the winter 1935–6, penultimate twigs apparently lost no water or the water was replaced from the older parts of the tree. From mid-March until the end of April a rapid increase in water content occurred, and it is safe to say that at the end of this period the wood was completely filled (the figures are somewhat *above* the average maximum possible water content for wood of paper birch). This coincides with a similar high figure for tops of field birch in the same year. A rapid decrease in water content followed until September, then an increase to an intermediate value. This is very like the behaviour of the other birches.

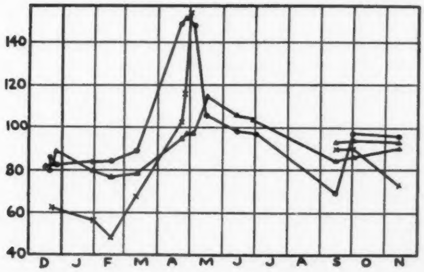

FIG. 2. *White birch variety: seasonal changes in water content of buds (crosses), wood of penultimate twigs (dots), and entire ultimate twigs (triangles), during 1935–6.*

The figures for ultimate twigs (very slender and pendulous in this tree) are for the whole twig, including cortex, but excluding buds. Here there is a slight drop in water content during the winter, an increase to a maximum in mid-May, a decrease between then and September and a slight rise in the fall. The ultimate twigs have, of course, become penultimate by that time.

Buds from these shoots lose water in winter (and this loss may in some cases, perhaps, be very serious), then show a rapid gain until at time of opening they have as much water as the wood of penultimate twigs.

3. Aspen Poplar (*Populus tremuloides* Michx.)

As in the case of paper birch an effort has been made to supplement the figures obtained for large trees in 1929–31. The results are summarized in Figs. 1 and 5 and in Table VI. Here, too, there is a marked drop in water content between December and April. It is more rapid than in birch and this is in line with the observations on evaporation from the surfaces of the two trees (8, Table II). The figures obtained on May 20, 1937, are low, but this may really represent in part a rapid fall in water content following leaf opening, for poplar (which is always a little ahead of birch) was just in leaf at this time.

In addition to determinations of water contents in these old trees, a large number of measurements have been made during 1935–8 on trees of three different ages, on the Island of Montreal. These were all young trees, the oldest have a D.B.H. of 2 to 4 in., the next younger a D.B.H. of 1 to 1½ in., and the youngest (which were almost unbranched) a diameter at the butt of about an inch. It was hoped that these investigations would give us some idea of the effects of age upon the water economy of the tree, but aspen is perhaps an unfortunate choice for this. Its water content is found to be extremely variable, and an enormous number of determinations would be necessary before any detailed conclusions could be drawn. The results are summarized in Tables I and VI and in Figs. 1 and 5.

TABLE I

WATER CONTENTS OF WOOD OF *Populus tremuloides* AT STE. ANNE DE BELLEVUE, 1935–8

Month	Year and part of tree	D.B.H., 2–4 in.		D.B.H., 1–1½ in.		D. at butt *ca.* 1 in.		Averages (No. of trees in parentheses)
January	Year	1936		1936	1937	1936	1937	
	T*	—		—	103	—	99	101 (6)
	T	110		119	135	123	117	119 (15)
	M	164		141	155	153	137	152 (15)
	B	142		145	151	125	129	139 (15)
February	Year	1936		1936				
	T	103		115		—		109 (6)
	M	159		138		—		149 (6)
	B	143		136		—		140 (6)
March	Year	1936		1936		1936	1936	
	T	86		119		107	104	104 (12)
	M	132		140		135	122	134 (12)
	B	110		139		127	128	126 (12)
April	Year	1936	1936	1936		1936		
	T	97	118	115		113		112 (12)
	M	136	143	151		143		145 (12)
	B	122	129	150		140		139 (12)
May	Year	1936		1936		1936		
	T	112		131		107		117 (9)
	M	86		129		117		111 (9)
	B	75		125		104		101 (9)
June	Year	1936		1936	1936	1936	1936	
	T	129		128	132	126	118	127 (15)
	M	90		120	130	123	106	110 (15)
	B	68		102	98	109	91	89 (15)
September	Year	1936		1936		1936		
	T*	78		78		84		80 (9)
	T	87		90		94		90 (9)
	M	70		96		96		87 (9)
	B	57		79		85		74 (9)
October	Year	1936	1936	1936	1936	1936	1936	
	T*	98	103	88	—	89	97	94 (15)
	T	103	118	103	74	94	114	102 (18)
	M	98	126	111	79	111	124	108 (18)
	B	71	93	90	72	92	106	87 (18)

T* = *Ultimate twigs*, T = *"top"*, M = *"middle"*, *and* B = *"butt" as usual. Three trees in each group.*

TABLE I—*Concluded*

WATER CONTENTS OF WOOD OF *Populus tremuloides* AT STE. ANNE DE BELLEVUE, 1935–8—*Concluded*

Month	Year and part of tree	D.B.H., 2–4 in.		D.B.H., 1–1½ in.		D. at butt *ca.* 1 in.		Averages (No. of trees in parentheses)
November	Year	1938	1938	1936	1938	1936	1938	
	T*	—	—	105	—	113	—	109 (6)
	T	85	106	131	89	125	92	105 (18)
	M	99	141	148	111	141	113	129 (18)
	B	89	118	150	116	137	96	118 (18)
December	Year	1935	1936	1938	1938	1938	1938	
	T*	—	99	—	—	—	—	99 (3)
	T	115	109	103	116	101	102	108 (18)
	M	141	121	140	138	120	139	133 (18)
	B	127	115	125	124	96	127	119 (18)

T* = *Ultimate twigs,* T = "*top*", M = "*middle*", *and B* = "*butt*" *as usual. Three trees in each group.*

As in the case of the larger trees, there is a rapid and complete refilling of the functional wood in the autumn. During the period January-March there is some loss of water from the exposed parts of the tree, but this is surprisingly small, particularly in the smallest trees. It is difficult to understand this. There is an upswing in water content just before leaf opening, and it is noteworthy that the curve for "top" (2-year-old twigs in these trees) lags behind those for "butt" and "middle", continuing to rise until June. The significance of this will be discussed in a later section. There is a marked fall in water content during the summer to a low value in September (no figures are available for July and August).

The results, then, are not very different from those for the larger trees, and it is possible to say that after making some allowance for the heartwood in the older trees (it is never very extensive in poplar), the size of the tree has little effect on water content.

4. FIELD BIRCH (*Betula populifolia* Marsh.)

One of the major difficulties in work of this nature is to obtain unlimited supplies of suitable trees in a convenient location. Through the kindness of Mr. Cleveland Morgan it has been possible to cut about 250 trees of this species from a very uniform stand at Ste. Anne de Bellevue, about 20 miles from Montreal. These trees average 15 to 20 ft. in height and 2 to 4 in. D.B.H. The tremendous importance of this accessibility will be realized when it is remembered that not a few of these trees have been cut under appalling conditions in sub-zero weather. Skis and snowshoes have been used on some occasions.

It is hoped to continue work on field birch for several years in order to get as complete a picture as possible of the effects of environmental conditions upon water economy and to provide a "normal" basis for experimental work. Investigation of this species was started in November 1935 and is still (March, 1939) in progress. The results to date are summarized in Tables II and VI and in Figs. 3 and 5.

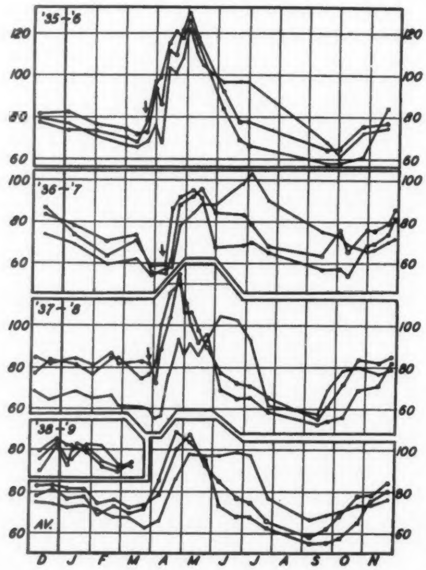

FIG. 3. *Water contents of field birch, 1935–9. Results are for "top" (dots), "middle" (circles) and "butt" (squares). The arrows represent times at which soil thawed at a depth of 4 in. (see text and Fig. 4).*

Let us consider the general picture as presented bv the curve averaging the results for this period.

The water content at the end of the year is about 80% for the whole tree and is not very different in samples from butt, middle, and top. This value is almost exactly the same as that for paper birch at the same time. There is a slow decrease in water content throughout the winter to a low value in mid-March of about 70% for the whole tree. The top is distinctly drier than the butt and middle at this time. A rapid filling of the tree follows, the top lagging somewhat, and *on the average*, the tree reaches a maximum water content of a little over 100% at the end of April. It is not completely full, however. From the time of leaf opening (the first week of May) a rapid decrease in water occurs, reaching a minimum of about 60% in September. It will be seen that the top again lags, retaining its maximum water content—just below 100%—for two months. At first sight this would seem to be evidence against

TABLE II

WATER CONTENTS OF WOOD OF *Betula populifolia* AT STE. ANNE DE BELLEVUE, 1935–9

Date	Part of tree	Year					Average
		1935	1936	1937	1938	1939	
Jan. 1–15	T	—	77	69	68	75 (6)	72 (15)
	M	—	83	78	84	82 (6)	82 (15)
	B	—	74	74	81	79 (11)	77 (20)
Jan 16–31	T	—	—	—	65	81	73 (6)
	M	—	—	—	80	80	80 (6)
	B	—	—	—	77	81	79 (6)
Feb. 1–15	T	—	71	60	—	82	71 (9)
	M	—	76	70	—	72	73 (9)
	B	—	73	63	—	74	70 (9)
Feb. 16–28 or 29	T	—	66	—	63 (9)	72 (4)	67 (16)
	M	—	75	—	84 (9)	70 (4)	76 (16)
	B	—	70	—	84 (9)	72 (4)	75 (16)
Mar. 1–15	T	—	66	62	—	72 (5)	67 (11)
	M	—	71	73	—	74 (5)	73 (11)
	B	—	67	73	—	74 (5)	71 (11)
Mar. 16–31	T	—	72 (6)	55	60 (6)		62 (15)
	M	—	83 (6)	56	82 (6)		74 (15)
	B	—	88 (6)	57	75 (6)		73 (15)
April 1–15	T	—	85 (6)	57	56 (6)		66 (15)
	M	—	99 (6)	56	81 (6)		79 (15)
	B	—	107 (6)	57	91 (6)		85 (15)
April 16–30	T	—	104 (6)	68 (6)	85 (9)		86 (21)
	M	—	115 (6)	75 (6)	111 (9)		100 (21)
	B	—	120 (6)	89 (6)	115 (9)		108 (21)
May 1–15	T	—	117 (6)	84	93 (6)		98 (15)
	M	—	125 (6)	95	102 (6)		107 (15)
	B	—	122 (6)	95	96 (6)		104 (15)
May 16–31	T	—	105	89	93		96 (9)
	M	—	—	93	90		92 (6)
	B	—	—	92	95		94 (6)
June 1–15	T	—	96	87	104		96 (9)
	M	—	93	85	77		85 (9)
	B	—	84	67	68		73 (9)
June 16–30	T	—	97	98	102		99 (9)
	M	—	77	82	71		77 (9)
	B	—	69	68	64		67 (9)
July 1–15	T	—	97	103	93		98 (9)
	M	—	78	79	71		76 (9)
	B	—	66	70	65		67 (9)
July 16–31	T	—	—	90[1]	62[2]		76 (6)
	M	—	—	66	63		65 (6)
	B	—	—	65	59		62 (6)

Values are averages for 3 trees except where otherwise indicated in parentheses.

[1] *Obtained by J. H. Whyte and D. Siminovitch.*

[2] *Obtained by D. Siminovitch.*

TABLE II—*Concluded*

WATER CONTENTS OF WOOD OF *Betula populifolia* AT STE. ANNE DE BELLEVUE, 1935–9—*Concluded*

Date	Part of tree	Year 1935	1936	1937	1938	1939	Average
Sept. 1–15	T	—	—	75	57[2]	·	66 (6)
	M	—	—	64	53		59 (6)
	B	—	—	57	53		55 (6)
Sept. 16–30	T	—	68	—	69		69 (6)
	M	—	66	—	60		63 (6)
	B	—	58	—	54		56 (6)
Oct. 1–15	T	—	62	71 (6)	75		69 (12)
	M	—	64	71 (6)	72		69 (12)
	B	—	59	56 (6)	55		57 (12)
Oct. 16–31	T	—	73	67	80		73 (9)
	M	—	75	77	83		78 (9)
	B	—	60	68	69		66 (9)
Nov. 1–15	T	—	76	69	76		74 (9)
	M	—	77	76	81		78 (9)
	B	—	84	69	71		75 (9)
Nov. 16–30	T	—	—	71 (6)	80		76 (9)
	M	—	—	83 (6)	83		83 (9)
	B	—	—	78 (6)	82		80 (9)
Dec. 1–15	T	80	74	68	76		75 (12)
	M	80	84	85	80		82 (12)
	B	78	86	77	70		78 (12)
Dec. 16–31	T	—	—	64	83		74 (6)
	M	—	—	81	84		83 (6)
	B	—	—	82	82		82 (6)

Values are averages for 3 trees except where otherwise indicated in parentheses.
[1] *Obtained by J. H. Whyte and D. Siminovitch.*
[2] *Obtained by D. Siminovitch.*

the existence of continuous water columns from butt to top, but an investigation of *distribution* in the tree suggests that this is misleading. More detailed work is desirable, but a few determinations indicate that the outer parts of the butt (which are in direct connection with the wood at the top of the tree) have about the same water content as the top. Thus on July 4, 1938, the average water content at the tops of three trees was 93%, the value for the outer wood at the butt was 85%. The average for the whole butt, however, was only 65%, the distribution from outside to centre being as follows: 85, 55, 62, 64, 68%. It will be remembered that the tops of the small poplars showed a similar lag (Fig. 1). The outer sapwood of hemlock, too, has a high water content at the end of June (Fig. 6). From September until about the end of the year there is a steady increase in water content to about 80%.

The behaviour, then, is very much as in paper birch: a depletion of water content in winter (when uptake is hindered) and in summer (when the tree is in leaf), a refilling (which may be incomplete) in April and in autumn. This is likely, one feels, to be a general picture for hardwoods.

Have other investigators found similar figures? The work of Hartig (12–14), Tonkel (see Büsgen (1)), and Geleznow (4) is not sufficiently complete to make comparison easy. Geleznow's figures, especially, are difficult to reconcile with our own. He gives one value (expressed on a fresh weight basis) for *Betula alba* near Moscow which corresponds with a dry weight figure of about 285%. This might be a possible figure for balsam fir, but it is about double the possible maximum for birch, and one wonders if his other figures are reliable. Tonkel's work is more in line with our own, but he apparently gives no figures for the period March-June and so misses the spring maximum. Hartig's figures are fairly complete. He records a maximum of about 100% for birch at the end of March, a minimum of about 75% in September and a value of around 85% in the middle of winter (see 7, Fig. 4).

Let us consider next the results for individual years. In the winter of 1935–6 there was a slight but steady fall in water content until about mid-March; in 1936–7 similar trees (with about the same water content in November) lost about the same amount of water by mid-March but continued to

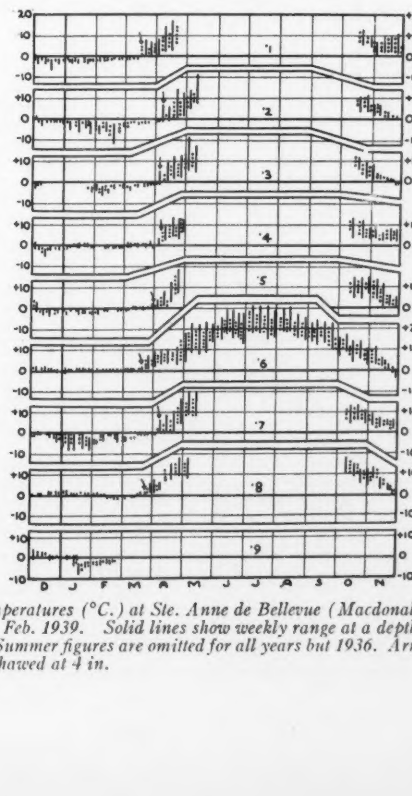

FIG. 4. *Soil temperatures (°C.) at Ste. Anne de Bellevue (Macdonald College) during the period Dec. 1930 to Feb. 1939. Solid lines show weekly range at a depth of 4 in., dotted lines the range at 8 in. Summer figures are omitted for all years but 1936. Arrows indicate probable dates at which soil thawed at 4 in.*

lose water until almost mid-April, while in 1937–8 the trees lost water only in their upper parts, the water content of butts and middles remaining at about 80% (the usual year-end value) until the end of March. During the present winter results seem unusually irregular but the figures suggest a slight loss to date (March 8). Can these differing behaviours be explained?

Fairly complete meteorological data are available (Table IV) from McGill Observatory and St. Hubert Airport. In addition, soil temperatures at 4 and 8 in. have been recorded at Ste. Anne de Bellevue (Fig. 4). Soil temperatures

TABLE III

PHENOLOGICAL AND OTHER DATA

Observations	Year				Remarks
	1936	1937	1938	1939	
Maple sap flow at Ste. Anne de Bellevue	—	Mar. 12	Mar. 24	V. slight, Mar. 12 – 14 and 23–24.	Same trees. Not necessarily the earliest date.
First week with mean air temp. over 40° F.	Mar. 16–22	April 8–24	Mar. 18–24		McGill Observatory.
Thawing of soil at 4 in. Thawing of soil at 8 in.	Mar. 20 Mar. 23	April 6 April 9	Mar. 27 Mar. 29		Macdonald College, Ste. Anne de Bellevue, Fig. 4.
General soil temperature during winter	High	Low	High: lower at end	High first half; low second half.	Fig. 4.
Loss of water by field birch in winter	Steady but slight	Large	Very slight except in twigs	Slight; irregular to Mar. 8	Fig. 3.
Increase in water content of field birch	*ca.* Mar. 15	*ca.* April 15	*ca.* April 4		Fig. 3.
Alder catkins expanded Alder catkins dehiscing	Mar. 31 —	April 10 April 17	April 9 April 16		
Earliest maple in flower	—	April 15	April 7–8		Same tree.
Field birch bleeding	Mar. 31* April 25	April 17 April 27	April 16 April 23		*Stumps of cut trees.
Field birch catkins expanded Field birch catkins dehiscing	May 2 Before May 10	— May 8	April 30 After May 5		
Bark of field birch slipping:— At top At butt	 Before April 25? May 10	 April 27 May 8–16	 April 23 May 5		
Buds of field birch showing *ca.* ¼ in. of green	—	May 8	April 30		
Max. water content at butt and middle of field birch	*ca.* 130% *ca.* May 2	*ca.* 95% *ca.* May 8	*ca.* 123% *ca.* April 23		Fig. 3.

in 1935–6 and in 1937–8 were generally high, remaining at or a little above 0° C. for much of the time. Definite increases and daily fluctuations in soil temperatures, representing thawing at 4 and 8 in., occurred between March 20 and 23 in 1936 and March 27 and 29 in 1938. These dates correspond very closely with the first increases in water content recorded in those years (Table III). It is obvious, therefore, that something other than soil temperature is responsible for the different behaviours of the trees during these two winters. In 1937, soil temperatures were very low from early December until late March, and the soil finally thawed at 4 and 8 in. between April 6 and 9. This was reflected in the behaviour of field birch, for in this year all parts of the trees lost water until almost mid-April. During the present winter, soil

TABLE IV

ABSTRACT OF METEOROLOGICAL DATA

Observations	Month	1935–1936	1936–1937	1937–1938	1938–1939
Mean temp. (°F.) for month, and range of daily means (in parentheses) (McGill Observatory)	Dec.	16 (−1 to 35)	29 (5 to 42)	19 (−3 to 32)	24 (2 to 41)
	Jan.	13 (−10 to 34)	24 (1 to 41)	15 (−5 to 38)	15 (−9 to 42)
	Feb.	12 (−2 to 36)	23 (7 to 39)	17 (−1 to 35)	16 (−2 to 29)
	Mar.	33 (8 to 48)	24 (8 to 35)	27 (−3 to 49)	
Relative humidity (McGill Observatory)	Dec. Jan. Feb. Mar.	79 82 77 72	72 77 77 70	60 75 79 82	80 79 81
Rain (in.) Snow (in.) Rain and melted snow (in.) (McGill Observatory)	Dec.	0.3 14 1.8	2.4 19 4.4	0 37 4.3	2.1 15 3.9
	Jan.	0.5 34 4.3	3.8 12 5.7	0.9 15 2.4	1.3 21 3.4
	Feb.	0.2 31 3.6	1.1 15 2.6	1.6 18 3.7	0.5 39 5.1
	Mar.	5.2 13 7.3	0 36 3.5	1.4 17 3.7	
Percentage possible sunshine (McGill Observatory)	Dec. Jan. Feb. Mar.	24 26 46 30	25 27 33 31	28 31 34 37	21 30 28
Mean vel. of wind (miles per hr.) (St. Hubert Airport, Que.)	Dec. Jan. Feb. Mar.	10 12 14 12	13 15 12 13	12 12 11 11	13 14 16

temperatures have been low after a very mild December. This record is incomplete at the time of writing.

Let us consider for a moment the question of movement of water into and through the tree during the winter months, for this might explain the data obtained. It is certain that the trees investigated are frozen for a part of the time, but it is also a matter of observation that they thaw during mild weather, even when the air temperature is somewhat below freezing point. It is quite possible that a slow movement of water *through* the tree can take place under these conditions, but can water *enter* the tree?

This question cannot yet be answered with certainty, but a few experimental results (summarized in Table V) may be considered here.

On January 16, 1937, several small branches were cut from trees of field birch at Ste. Anne de Bellevue and analyzed. Entire ultimate twigs of these (*i.e.*, those formed the previous summer) had 73% of water, while the penul-

TABLE V

WATER CONTENTS OF AMPUTATED PARTS OF FIELD BIRCH

Expt. nos. and dates	Part cut and treatment given	Entire penultimate twig		Entire ultimate twig		Remarks
S.A. 37.4, Jan. 16, and S.A. 37.13, Mar. 29.	Freshly cut branches, Jan. 16	75		73		There was no recorded increase in water content of the trees as a whole until after April 11. Cut ends of branches painted and wrapped in rubber.
	Similar branches, cut Jan. 16, left tied to trees until Mar. 29, then analyzed.	38		37		
	Freshly cut branches, Mar. 29	57		67		
S.A. 37.7, Feb. 13, and S.A. 37.13, Mar. 29.	Freshly cut branches, Feb. 13	63		72		
	Similar branches, cut Feb. 13, left tied to trees until Mar. 29, then analyzed.	47		47		
	Freshly cut branches, Mar. 29	54		67		
		Butt	Butt[1]	Middle	Top	
S.A. 38.7, Feb. 26 and S.A. 38.12, April 1.	Freshly cut trees (6) Feb. 26	84	—	83	61	[1]Cut midway between butt and middle.
	Trees (3) cut Feb. 26, left guyed in position on stump until April 1, then analyzed.	—	59	68	55	[2]High values probably partly due to spring increase. See text.
	Freshly cut trees (3), April 1	82[2]		73[2]	55	
S.A. 39.2, Jan. 11, S.A. 39.3, Jan. 14, and S.A. 39.9 Mar. 8.	Freshly cut trees, Jan. 11 (3) and 14 (2).	81[3]	—	81	75	[3]Includes butt values of trees cut and guyed.
	Trees cut Jan. 11 (3) and 14 (2), left guyed in position on stump until Mar. 8, then analyzed.	—	76	76	71	Cut ends painted and wrapped in rubber.
	Freshly cut trees (5), Mar. 8	74	75	74	72	

timate twigs had 75%. Exactly similar branches were cut at the same time, their ends were painted and tightly wrapped in rubber, and they were then tied to the trees in the positions they had occupied. Ten weeks later (on March 29) they were analyzed, as were freshly cut "control" branches. They were found to contain 37% and 38% of water in ultimate and penultimate twigs, while the "controls" had 67% and 57% respectively. A second set was treated similarly from Feb. 13 until March 29. In this case, too, the detached twigs had lower water contents than those still attached to the tree (47% and 47% against 67% and 54%). It would seem from this that water had moved into the attached twigs, but this may have happened just prior to March 29, though it should be emphasized that no increase in water content of the trees as a whole was registered until after April 11.

A similar experiment was carried out in 1938, but in this case whole trees were cut, the ends sealed and the trees guyed in their original positions. They were cut on February 26 and analyzed on April 1. This experiment was inconclusive as the control trees cut on April 1 were already taking up water. However, it is clear that the *tops* of the detached trees were no drier than those of the controls, which probably had received none of the water taken up from the soil in the few days prior to cutting.

In the present year a further experiment with cut trees gave very uniform results, the water contents of three trees cut on Jan. 11, and two on Jan. 14, and left guyed in position until March 8 being almost exactly the same as those of attached trees freshly cut on March 8. Here there is absolutely no evidence of movement *into* the control trees; but on the other hand there has been remarkably little loss either from detached or from attached trees during the seven weeks of almost continuously cold weather. It is obvious that a much more extended series of experiments is needed, and these are planned for the next winter.

Are some of the differences in winter behaviour of field birch to be attributed to differing rates of evaporation during the winters studied? Apparently no agency measures evaporation during the winter, so no comparative figures are available. A consideration of the meteorological data given in Table IV permits of no very definite conclusions. Temperatures in 1937–8 were between those of 1935–6 and 1936–7; humidity was at first lower, then higher than in those years; wind was a little lower; sunshine generally higher. This would not point to greatly reduced evaporation in 1937–8.

The most likely explanation of the high figures for water in butts and middles of field birch during the winter of 1937–8 would seem to be uptake of water from the soil, but as we have seen above this did not appear to occur in 1935–6, although soil-temperature conditions were similar.

It may be a matter of coincidence, but during these three winters the dates of thawing of the soil, of a weekly mean air temperature of 40° F., and of first increases in water content have shown a close correspondence (Table III).

The spring rise in water content during 1936 lasted from mid-March until the beginning of May—about six weeks—and resulted in an increase from

about 70% to nearly 130%, at which figure the trees were nearly saturated. In 1937 the increase occurred during about a month (mid-April to mid-May) —except in "tops"—and resulted in an increase from about 57% to about 94%. It seems that the trees had time to fill only partially in this year before the leaves opened. It will be remembered that paper birch from above Chicoutimi had a water content of about the same value at about the same time (Fig. 1). In 1938, when the increase started at about the end of March and continued until barely a month later, the water content rose almost to the 1936 figure of 130%, but this was from a "low" of about 80%.

The outer parts of the trees (and hence the figures for "tops") seem always to lag somewhat behind the inner parts (and hence behind the averages for "butts" and "middles"). This is particularly noticeable in the record for 1937, when the maximum for the tops was 103% in early July; but the behaviour in 1938 was similar and even in 1936, when the lag was least obvious, a fairly high water content persisted in the tops until the end of June.

The phenological and other data given in Table III are admittedly incomplete, but they indicate that although the spring of 1937 started late there was little difference between the years 1936, 1937, and 1938 by the end of April. An examination of the soil temperatures given in Fig. 4 further shows that the spring of 1937 was about as late as any between 1931 and 1939, while those of 1936 and 1938 were about as early as any. In short we have struck, in all probability, the approximate limits for this season in the years under consideration.

In the three years for which figures are available the late summer minimum has been about the same. Figures for this season are not sufficiently numerous, however, to make accurate comparisons possible. It is doubtful if the trees suffered from any real shortage of water in the summers studied, because the month by month precipitation from May to September in 1936 was 4.1, 2.9, 4.7, 4.2, and 2.2 in. In the same period of 1937 it was 4.5, 4.0, 5.3, 3.5, and 3.1 in., while for 1938 it was 3.7, 3.4, 3.5, 5.8, and 6.5 in. It would be interesting, nevertheless, to investigate the effects of irrigation upon water content, and it is hoped to do this in the near future.

In each of the four years for which December figures have been obtained a water content of about 80% is indicated.

Weight and Density of Freshly Cut Hardwoods

It was mentioned in a previous section of the present paper that early work on water contents was carried out in connection with the sinkage problem. It is interesting to see how the more extensive figures now available for seasonal changes in water content apply to flotation and transportation.

A cubic foot of water weighs 62.5 lb. If a cubic foot of freshly cut wood weighs 62.5 lb. it will just float—*i.e.*, its density is 1.0. Poplar with this density would contain about 138% of water: paper birch about 100%. Any decrease in water content from these figures would result in a corre-

TABLE VI

WATER CONTENTS, DENSITIES AND WEIGHTS OF FRESHLY CUT HARDWOODS

Time of cutting	Aspen poplar (old trees; D.B.H. about 8 in.; 40 mi. N. of Chicoutimi)			Aspen poplar (young trees D.B.H. 1–4 in.; Island of Montreal)			Paper birch (old trees; D.B.H. about 8 in.; 40 mi. N. of Chicoutimi)			Field birch (young trees, D.B.H. 2–4 in.; Island of Montreal)		
	Water content (% based on dry weight)	Density (water = 1.0)	Weight, lb. per cu. ft.	Water content (% based on dry weight)	Density, (water = 1.0)	Weight, lb. per cu. ft.	Water content (% based on dry weight)	Density (water = 1.0)	Weight, lb. per cu. ft.	Water content (% based on dry weight)	Density (water = 1.0)	Weight, lb. per cu. ft.
January	111	0.89	56	**145**	**1.03**	**63**	82	0.91	57	79	Cannot be calculated accurately from our records but will compare closely with paper birch.	
February	111	0.89	56	**145**	**1.03**	**63**	80	0.90	56	74		
March	–	–	–	126	0.95	60	–	–	–	72		
April (early)	92	0.82	51	140	1.01	62	78	0.88	55	81		
April (late)	124	0.95	59				91	0.95	59	**103**		
May	90	0.80	50	108	0.87	55	91	0.95	59	99		
June	–	–	–	100	0.83	53	**92**	**0.96**	**60**	80		
July	87	0.78	49	–	–	–	**54**	**0.77**	**48**	70		
August	81	0.76	47	–	–	–	**54**	**0.77**	**48**	–		
September	**68**	**0.70**	**43**	**80**	**0.75**	**47**	62	0.81	51	**59**		
October	98	0.83	52	98	0.83	52	80	0.90	56	68		
November	–	–	–	122	0.93	59	85	0.93	58	79		
December	**135**	**0.99**	**62**	125	0.94	60	–	–	–	81		

Maxima and minima in all cases in **bold face type.**

sponding decrease in weight and a greater margin of flotation. Increased flotation is important in the "driving" of logs, while decreased weight is obviously of great importance for haulage. It will be seen from Table VI and Fig. 5 how these figures change with the season in the case of birch and

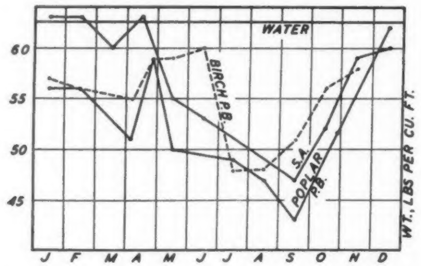

FIG. 5. *Seasonal changes in weight of freshly cut wood of paper birch and aspen poplar from Price Bros. limits above Chicoutimi and of aspen poplar from Ste. Anne de Bellevue.*

poplar*. From them we learn that a cubic foot of young poplar cut in January may weigh 63 lb. (*i.e.*, it will sink at once if placed in water), while wood from the same tree cut in September will have a density of about 0.75 and will weigh more than 25% less. Birch shows similar changes. This is obviously of considerable practical interest and our knowledge of such facts should be extended to all commercial species.

5. HEMLOCK (*Tsuga canadensis* Carr.)

Between November, 1936 and June, 1938, 46 young hemlock trees, averaging a little over 5 in. D.B.H., were cut at Ste. Anne de Bellevue. These grew in a mixed woodland very near the stand of field birch described in the previous section. The results from these trees are summarized in Fig. 6 and in Table VII.

Hemlock, like poplar, varies greatly from tree to tree, the sapwood being relatively narrow and the heartwood (as in balsam fir) having wet and dry patches. This variability makes it necessary to cut a large number of trees in order to get really accurate figures, and the 46 trees used here are not enough for detailed conclusions. It is clear, however, that a marked seasonal variation in water content occurs in the sapwood, and that this parallels closely the behaviour of the outer wood of birch and poplar. There is a high water content at the end of the year, a distinct drop throughout the winter and a rise to a maximum in June. This is followed by a decrease during the summer to a low value in September or October and an increase from then until December. Since these changes are restricted to the sapwood, and since this is relatively narrow, the water contents of these trees *as a whole* show little change; older trees would show even less.

* *Some of these data have already been published (9).*

TABLE VII

WATER CONTENTS OF HEMLOCK AT STE. ANNE DE BELLEVUE, 1936–8

Date (No. of trees in parentheses)	Expm't nos.	Discs			Distribution											
					Butt				Middle				Top			
					Sapwood		Heartwood		Sapwood		Heartwood		Sapwood		Heartwood	
		Butt	Middle	Top	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner
January (4)	37.2 37.5 38.1	100	112	122	128	100	84	95	143	114	88	101	149	119	94	77
February (5)	37.6 37.8 38.4 38.5	88	101	114	102	69	80	104	125	88	86	97	143	102	90	99
March (6)	37.9 37.11 37.12 38.8 38.9	93	107	113	122	89	74	87	136	113	86	99	130	104	108	94
April (4)	37.14 37.16 37.18	78	90	113	84	69	79	82	104	71	89	107	136	96	100	101
May[1] (4)	37.20 37.22 37.23	87	87	103	87	63	91	111	107	73	72	104	121	77	106	104
June[2] (6)	37.24 37.25 37.26 37.27 38.21	94	104	118	123	81	80	98	135	101	84	84	150	104	97	94
September (4)	37.30 37.31	76	101	118	84	56	65	115	107	81	114	108	136	107	108	107
October (4)	37.33 37.34	86	91	104	97	74	85	102	113	83	80	87	122	92	84	99
November (5)	36.35 37.37 37.38 37.39	94	113	124	112	81	89	95	134	108	98	116	147	112	108	101
December (4)	36.37 36.39 37.42	104	119	139	134	100	76	95	152	111	101	90	167	122	122	98

[1] *Includes two trees cut June 1.*
[2] *Includes one tree cut July 6.*

TABLE VIII

WINTER WATER LOSSES OF LARCHES, PINES, HEMLOCK, AND DOUGLAS FIR

Dates	*Larix laricina* Three trees, D.B.H. 5–6 in., Price Bros. limits above Chicoutimi, 1936–7	*Larix europaea* One tree, *ca.* 8 ft. high, at McGill, 1938–9		*Pinus strobus* Old trees at Ste. Anne, 1936–7			*Pinus ponderosa* Trees near Pullman, Washington, U.S.A. (Clements*), 1936–7			*Tsuga canadensis* Old trees at Ste. Anne, 1936–7			*Pseudotsuga mucronata* Trees near Pullman, Washington, U.S.A. (Clements*), 1936–7		
	Sapwood (Av. of tops, middles, and butts)	Wood of 2-year old twigs[1]	Entire 1-year-old twigs[2]	Entire 2-year-old twigs	Entire 1-year-old twigs	Leaves[3]	Leaves of current year	Leaves 1-year-old	Leaves 2-year-old and older	Entire 2-year-old twigs	Entire 1-year-old twigs	Leaves[3]	Leaves of current year	Leaves 1-year-old	Leaves 2-year-old and older
Nov. 6	–	126	112	–	–	–	–	–	–	–	–	–	–	–	–
Nov. 7	–	–	–	104	133	141	–	–	–	106	93	138	–	–	–
Nov. 26	–	–	–	–	–	–	114	109	100	–	–	–	138	118	102
Dec. 5	–	–	–	118	131	139	–	–	–	96	75	137	–	–	–
Dec. 23	–	122	107	–	–	–	–	–	–	–	–	–	–	–	–
Dec. 27	–	126	108	–	–	–	–	–	–	–	–	–	–	–	–
Dec. 31	–	–	–	–	–	–	126	114	111	–	–	–	137	121	106
Jan. 16	–	–	–	108	129	142	–	–	–	**82**	69	134	–	–	–
Jan. 25	–	114	105	–	–	–	–	–	–	–	–	–	–	–	–
Jan. 27	–	113	105	–	–	–	–	–	–	–	–	–	–	–	–
Jan. 31	135	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Feb. 5	–	–	–	–	–	–	125	110	104	–	–	–	139	121	103
Feb. 14	–	117	103	–	–	–	–	–	–	–	–	–	–	–	–
Feb. 28	123	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mar. 5	–	–	–	–	–	–	123	111	104	–	–	–	130	116	101
Mar. 12	–	–	–	**96**	**106**	**130**	–	–	–	**83**	**63**	**132**	–	–	–
Mar. 17	–	106	**97**	–	–	–	–	–	–	–	–	–	–	–	–
Mar. 28	–	103	100	–	–	–	–	–	–	–	–	–	–	–	–
April 4	**107**	**102**	107**	–	–	–	–	–	–	–	–	–	–	–	–
April 8	–	–	–	–	–	–	**98**	**89**	**87**	–	–	–	**102**	**87**	**78**
April 10	–	106	105	117	144	142	–	–	–	91	72	139	–	–	–
April 20	–	–	–	116	133	142	–	–	–	86	75	129	–	–	–
May 20	121	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[1] [2] [3] *Results high by 2, 6, and 8% as indicated by distillation figures. Figures given were obtained by oven drying.*

* *Clements, H. F. Research Studies State Coll. Wash. 6 : 3-45. 1938. Clements' figures have been recalculated on a dry weight basis.*

** *After rain and wet snow.*

Minima in bold face type.

It should be remembered that results for jack pine, spruce, and balsam previously reported (7) do *not* indicate a similar seasonal cycle, but the figures for these were not sufficiently extensive to rule out *all* change and some re-examination of those trees is planned.

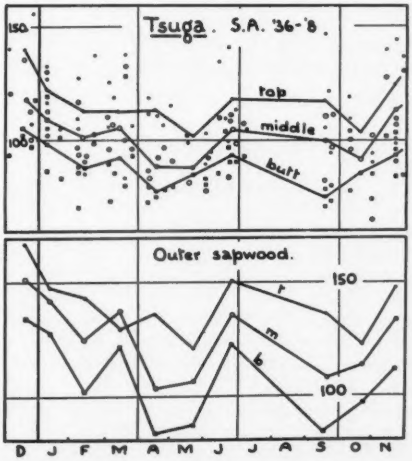

FIG. 6. *Water contents of hemlock at Ste. Anne de Bellevue 1936–8. Above—results from individual trees and averages for discs from tops, middles, and butts (dots, circles, and squares respectively). Below—water contents of outer sapwood.*

In addition to the observations on hemlock that are noted above some measurements have been made of the water contents of twigs and leaves of this species during the winter of 1936–7. These results, together with similar ones for white pine, some winter figures for *Larix europaea* and *L. laricina* and some figures obtained by Clements for *Pinus ponderosa* and *Pseudotsuga mucronata* in the State of Washington, are summarized in Table VIII.

In all these trees there is a definite loss of water during the winter. The loss is surprisingly small—less than 10%—in the coniferous leaves examined in Canada, but may be quite large—about 32%—in twigs of hemlock. Clements' figures indicate very little loss before early March, but a sharp drop between then and April 8. A similar drop may occur in the Canadian trees (no analyses were made between March 12 and April 10, but by the latter date the trees were obviously taking up water). Further investigation obviously is desirable.

Acknowledgments

This paper is an interim report so little needs to be said by way of conclusion. It remains to thank those who have made the work possible. Financial aid—by way of a research grant—has been received from the National Research Council, and some of the earliest figures were obtained

with the help of a grant from the Canadian Pulp and Paper Association. Hospitality and assistance in the field came from Price Bros. and Co., Ltd., through the kindness of Messrs. Jago and Walton. Many of the trees used in the present investigation were cut with the permission of Mr. Cleveland Morgan and some were donated by the Provincial Government. Dr. J. H. Whyte, Mr. D. Siminovitch, and Master Lloyd Scarth have given valuable aid. The author is indebted to Dr. W. Rowles of Macdonald College for soil temperature records, to McGill Observatory for weather data, and to Mr. Carmichael of St. Hubert Airport for wind velocities.

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CANADIAN JOURNAL OF RESEARCH

VOLUME 17
1939

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Canadian Journal of Research

Issued by THE NATIONAL RESEARCH COUNCIL OF CANADA

VOL. 17, SEC. D. DECEMBER, 1939 NUMBER 12

STUDIES ON THE ENDOPARASITIC FAUNA OF TRINIDAD MAMMALS

VI. PARASITES OF EDENTATES[1]

BY THOMAS W. M. CAMERON[2]

Abstract

Of the internal parasites from two species of anteaters and an armadillo from Trinidad, B.W.I., five species of nematodes are described as new to science, *viz.*, *Lauroia trinidadensis*, *Delicata pseudoappendiculata*, *Longistriata cristata*, *L. urichi*, and *Pintonema tamandua*.

There are three edentates found in the island of Trinidad, B.W.I. These are two anteaters and an armadillo.

Tamandua longicaudata (syn. : *T. tetradactyle*) or "Tamandua" is also called the Lesser Anteater to distinguish it from the Ant-bear. This latter animal is absent from the island, however, and the Tamandua is the largest species found there. It is essentially arboreal but is often found on the ground.

Seven individuals were available for examination.

Cyclopes pygmaeus (syn. : *C. didactylus*) or Silky Anteater, is known locally as the Sloth; the true sloth, however, is absent from Trinidad, although found on the adjacent mainland. The Silky Anteater is a tiny, arboreal creature, seldom descending to the ground on which it walks with difficulty.

Only two specimens were available for study and a single female trichostrongyle was the sole helminth recovered.

Tatusia novemcincta or Armadillo is the third edentate found in Trinidad; elsewhere this species is called the nine-banded armadillo. Its distribution extends into the southern United States. It is quite strictly terrestrial and is the only edentate found on other West Indian islands, occurring on Tobago and Grenada; it has possibly been introduced by man into Grenada at least.

Three armadillos were available from Trinidad.

I have again to express my indebtedness to the late Professor Urich and to Mr. Fitzgerald. They collected and shipped to Canada the entrails of the animals from which these specimens were obtained. The material was

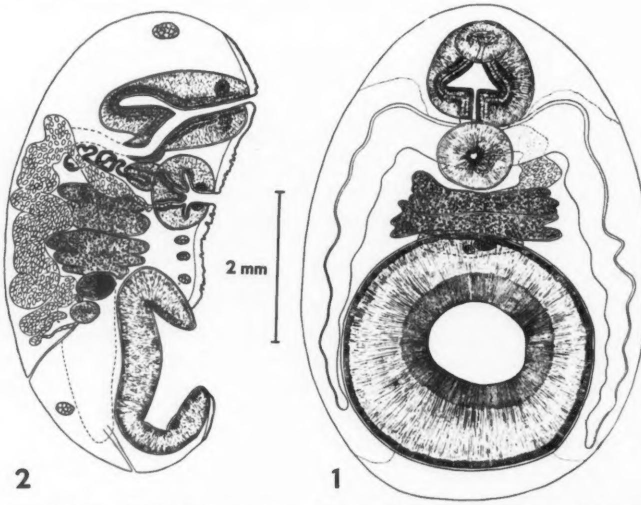
[1] *Manuscript received June 28, 1939.*
Contribution from the Institute of Parasitology, McGill University, Macdonald College, Quebec, with financial assistance from the National Research Council of Canada.

[2] *Professor of Parasitology, McGill University, and Director, Institute of Parasitology, Macdonald College, Canada.*

preserved in formalin in bulk, and then wrapped in formolized cloth, sealed in tins, and sent by parcel post. It arrived in excellent condition. After being soaked in water, the entrails were opened, and the parasites collected and preserved in a standard mixture of formolized glycerine alcohol.

Stichorchis giganteus (Diesing, 1835) Travassos, 1922

A number of amphistomes was found in the intestine of one Tamandua. Some of these were stained and mounted as whole mounts, others were serially sectioned. Figs. 1 and 2 are reconstructions of these from the ventral and lateral view-points. The specimens measure about 6 mm. long by 4.5 mm. wide by 2.75 mm. thick. They are oval in outline and flat on the ventral face. The mouth opening is at the anterior end of the ventral surface, the acetabulum at the posterior and the genital opening just in front of the middle. The cuticle on the ventral surface is much thicker than that over the remainder of the body.



FIGS. 1 and 2. *Stichorchis giganteus.* FIG. 1. *Reconstruction from serial sections of entire animal from ventral aspect.* FIG. 2. *Reconstruction from lateral aspect of medial serial sections.*

The acetabulum is massive, with a diameter of about 2.5 mm. The mouth is surrounded by an oral sucker and pharynx fused together; there is a pair of large posterior diverticula to the pharynx, one on each side. The oesophagus is short and has a muscular sphincter, quite distinct from that of the pharynx. The caeca are massive and extend to the posterior region of the body.

The genital opening is surrounded by a massive genital sucker into which open the male and the female ducts. The testes are slightly dendritic, tandem and close to each other. They are much wider and broader than long, and they occupy most of the space in the middle of the body between the anterior

margin of the acetabulum and the genital sucker. The vas deferens is much coiled in front of the anterior testis and forms a seminal vesicle. This is situated just behind the genital sucker but slightly to one side. Before it enters the sucker, it forms an S-shaped loop, and this part is surrounded by a glandular structure.

The ovary is small and spherical and lies just posterior to the posterior testis. The portion next to the oviduct is much more closely granular than the remainder. A shell gland lies just posterior and to one side of the ovary. The oviduct is narrow and much convoluted and appears to be filled with spermatozoa. Laurer's canal runs from this point to the dorsal surface of the body, opening directly behind the acetabulum. The uterus is thrown into a number of lateral loops on the dorsal aspect of the body. The uterus joins the genital sucker posterior to the vas deferens. There are numerous yolk follicles scattered about the body, mostly posterior and ventral to the other genitalia, but some in the anterior region of the body.

Two species of *Stichorchis* are known—one from the beaver, which is quite different, and one from porcine animals in South America, the peccary being apparently the original host. The recent re-description by Vas of *S. giganteus* from the pig in Brazil, shows that the present specimens are very closely related to it. The differences that exist are mainly those of dimensions and proportions. In general the sizes recorded for porcine material are larger; the present specimens were fixed in formalin *in situ* and may have shrunk considerably, while host environment may equally account for smaller size. Moreover, the Collared Peccary occurs in Trinidad, although *Stichorchis* has not yet been recorded from it there. Accordingly, these specimens from the Tamandua are referred to *S. giganteus*.

Oöchoristica spp. inq.

Fragments of tapeworms belonging to this genus were found in one Tamandua and one armadillo. It was impossible to identify the species in either case.

Gigantorhynchus echinodiscus (Diesing, 1851)

This thorny-headed worm was present in each Tamandua examined, sometimes in considerable numbers. It does not differ in any material manner from Travassos' description (1917).

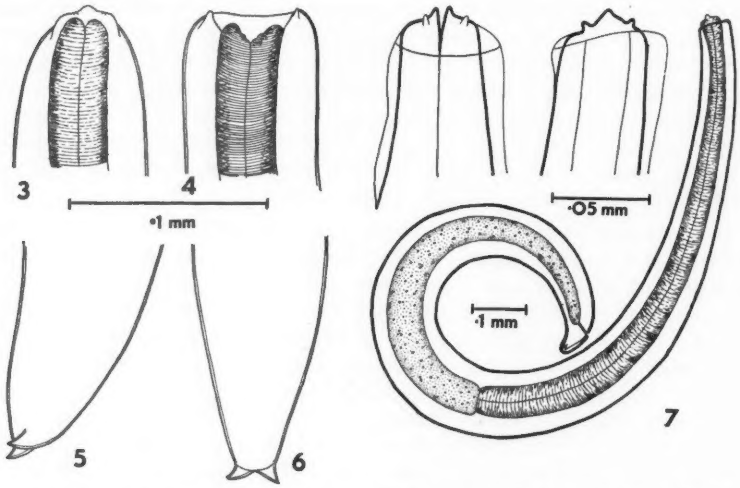
Strongyloides sp.

A single specimen of *Strongyloides* was found in the small intestine of a Tamandua. It was 3.6 mm. long. The oesophagus was 1.1 mm. long, and the vulva was situated 1.1 mm. from the tail, which was 0.05 mm. long and bluntly pointed. In view of the fact that a single formalin-fixed specimen is available, no attempt is made to assign it to a species.

Acanthocheilonema sp.

A single filaria worm was found on the outside of the intestine of one Tamandua. It was a female, 42 mm. long and 0.25 mm. wide. No transverse

striations were observed. The mouth (Figs. 3 and 4) is in a hollow with a pair of dorso-ventral lips. Each of these carries three papillae, the central one of which is on a projection; each lip accordingly is trilobed. The oesophagus is 1.3 mm. long and the anus opens 0.15 mm. from the tip of the tail. The tail is rounded with two lateral triangular projections (Figs. 5 and 6), one on each side; the apex of each triangle is directed ventrally, outwards and backwards.



FIGS. 3–6. *Acanthocheilonema* sp. FIG. 3. *Head of female from lateral aspect.* FIG. 4. *Head of female from ventral aspect.* FIG. 5. *Tail of female from lateral aspect.* FIG. 6. *Tail of female from ventral aspect.*

FIG. 7. *Physaloptera* sp. *Entire larval Physaloptera with insets showing details of head from ventral (upper right) and lateral aspects.*

The nerve ring is 0.2 mm. from the mouth opening with the excretory pore just in front of it. The vulva is situated 0.55 mm. from the mouth. The long slender ovejector joins the uterus just behind the end of the oesophagus. The ovarian tubules are double.

This parasite closely resembles the description of *Acanthocheilonema perstans*, a filariid parasite of man (which also occurs in Trinidad). It is, however, shorter (42 mm. as against 70 to 80 mm. long) and wider (0.25 mm. as against 0.12 mm. wide). The monkey fauna of Trinidad consists of a Red Howler (*Alouatta insularis*) and a Capucin (*Cebus appella*). I have had no opportunity of examining the viscera of either species, but no parasites have been reported from them. However, members of the genus *Acanthocheilonema* occur in South American monkeys elsewhere. The present specimen is considerably smaller than these also.

The absence of any males prevents a specific diagnosis although it certainly belongs to this genus.

Physaloptera sp.

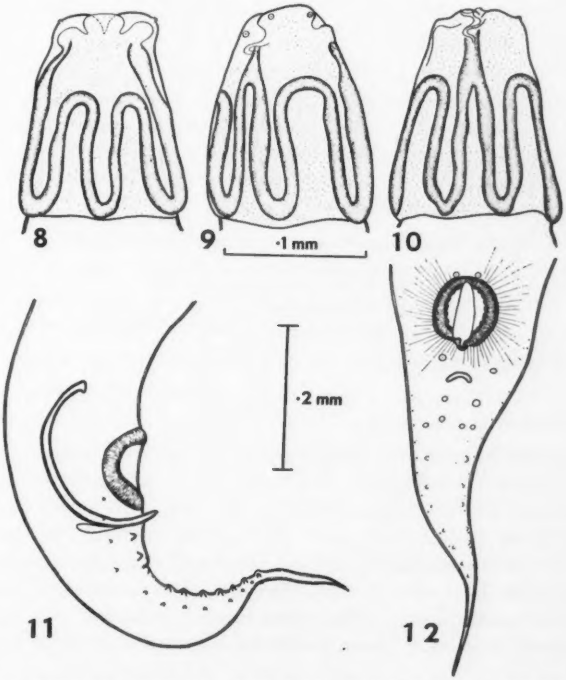
Five specimens of a larval Physaloptera were found in two Tamandua and one in an armadillo (Fig. 7). These all appear to be the same species. They are all small (2 mm.) with the oesophagus more than half the body length. The mouth has two projecting lips, each carrying three papillae. The tail is short and conical. There is no trace of any genitalia.

It is impossible to refer this species to any existing form. It is almost certainly abnormal in these edentates.

Aspidodera binansata Railliet and Henry, 1913

A considerable number of specimens, always in association with the next mentioned species, was found in the large intestine of all three armadillos; in one animal they occurred in the small intestine as well.

Both sexes are of about the same size, the average length being 5.5 mm. and the maximum width 0.5 mm. The body is finely striated throughout and lateral crests run from near the mouth to the anus. The cervical papillae lie in depressions in these crests.



FIGS. 8–12. *Aspidodera binansata.* FIGS. 8–10. *Head from dorsal, lateral, and ventral aspects; in Fig. 9 the dorsal face is next to Fig. 8.* FIGS. 11 and 12. *Tail of male from lateral and from ventral aspects.*

The head is similar in both sexes (Figs. 8, 9, and 10). The mouth is surrounded by three lips, each of which carries two small papillae. The dorsal lip is trilobed, the two others are simple. The head carries three sets of festoons, the function of which is not obvious although they may be glandular in nature. The dorsal festoon has two re-entrant loops, the others, one each. The outer limbs of each festoon unite to form an anterior projection; from each projection a small S-shaped duct runs forward to the inter-labial space. The contents of the festoons are granular and they move under pressure.

The head is distinctly separated from the remainder of the body by a constriction.

The oesophagus, which is 1.3 mm. long, has a distinct posterior dilation. The excretory pore, the nerve ring and the cervical papillae all lie about the middle of its length. The female tail is long and slender with a pair of small caudal papillae 0.35 mm. from the tip. The tail is 0.8 mm. long.

The entire genitalia is very compact and the ovaries are much coiled. The uteri are divergent but unite to form a long muscular ovejector which is directed forward to the vulva. The vulva lies just in front of the middle of the body. Each uterus contains about 40 eggs, which measure about 60μ by 40μ and have a thick shell.

The male tail is somewhat more sharply pointed than is that of the female. A conspicuous sucker is present just in front of the ano-genital opening (Figs. 11 and 12). This sucker is not complete posteriorly. Two papillae lie just in front of it and four rows of papillae run from its posterior margin towards the tip of the body. There is considerable irregularity both in the number and disposition of these papillae.

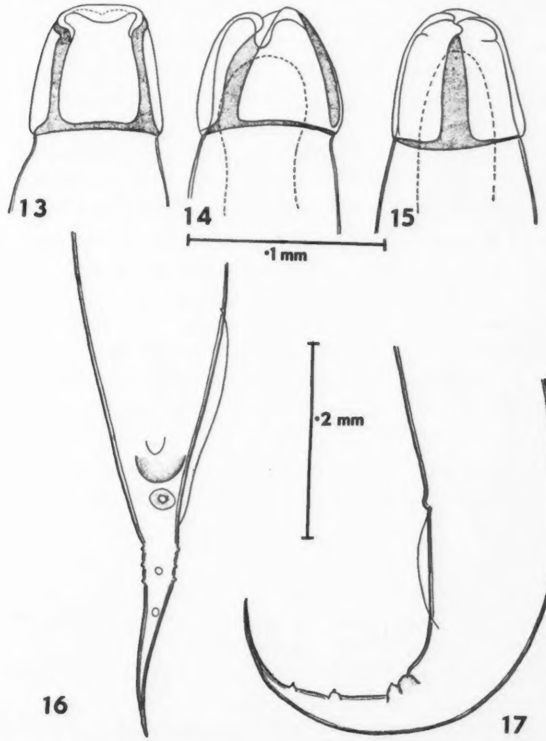
Two plain tubular spicules and an accessory piece are present. The spicules are 0.32 mm. long and the accessory piece about 0.1 mm. long.

A. fasciata (Schneider, 1866) has, *fide* Proença, a single re-entrant festoon on the dorsal face whereas this species has two. This would refer it to *A. binansata* Railliet & Henry, 1913, which Proença records from the same host in Brazil.

Lauroia trinidadensis sp. nov.

This parasite in considerable numbers was found in association with the previous species. The female is slightly larger (6 to 7 mm.) but the male is about the same size (5.5 mm.). The constricted head region in this species is very much smaller but there is a wide mouth opening, the base of which possesses a number of minute teeth. The head is surrounded by three flat cuticular plates (Figs. 13, 14, and 15). The dorsal one is rectangular with antero-lateral projections. The others are triangular, with interlocking antero-ventral margins. These plates are unstriated and no papillae were observed.

A narrow striated crest runs on each side of the body from just behind the head to the rectum.



FIGS. 13–17. *Lauroia trinidadensis* sp. nov. FIGS. 13–15. *Head from dorsal, lateral, and ventral aspects; in Fig. 14, the dorsal face is towards Fig. 13.* FIGS. 16 and 17. *Tail of male from ventral and from lateral aspects.*

The oesophagus is about 0.7 mm. long. The portion of the oesophagus within the head cap is separated from the remainder, which has a distinct bulb with a valvular apparatus. There are no intestinal diverticula at the oesophageal-intestinal junction. The excretory pore and nerve ring lie just about the middle of the oesophagus but no cervical papillae were seen.

The female tail is 0.75 mm. long and sharply pointed. It is conspicuously striated.

The vulva is at the junction of the anterior and middle thirds. It communicates with a long backwardly directed ovejector which splits into divergent parts. Each of these is continued as divergent uteri and ovarian tubules; each uterus with its tubules is confined to its own portion of the body. The eggs measure 65μ by 45μ and have thick shells.

The male tail is more sharply and abruptly pointed than is the female tail (Figs. 16 and 17). There is no sucker present but there is an asym-

metrical swelling or membrane on the left side of mature forms. This is not seen in young males. There are two central small, and one large, adanal papillae. Another papilla lies just anterior to the ano-genital opening. The tip of the tail is striated and carries three small lateral papillae and two medial post-anal papillae.

There is no gubernaculum. The spicules are subequal, the left measuring 0.8 mm. and the right 0.9 mm. The spicules end in fine points but are composed of a series of minute cuticular rings contained within a sheath.

Proença has recently (1938) described *Lauroia travassosi* from this host and *Dasypus sexcinctus* from Brazil. His specimens are not only larger than the Trinidad forms but differ from them in other details. The head plaques of the Trinidad species do not have the posterior appendices of the type; the spicules are sub-equal and much longer, and there is no true caudal sucker present. For these reasons this species is regarded as different and the name *L. trinidadensis* sp. nov. is proposed for it.

Trichocephalus sp. inq.

A single whipworm—a female in poor condition—was recovered from one Tamandua. Owing to this, no attempt has been made to describe it or refer it to a species.

Graphidiops costalimai Lent & Freitas, 1938

This species is common in the Tamandua. The female is 6 mm. long and the male about 4 mm. long. The body is finely striated. The head is slightly swollen and the striations are more conspicuous.

The mouth is surrounded by six minute papillae but is otherwise simple (Fig. 18).

The oesophagus is 0.5 mm. long, with the excretory pore about its mid-point and the nerve ring slightly behind this.

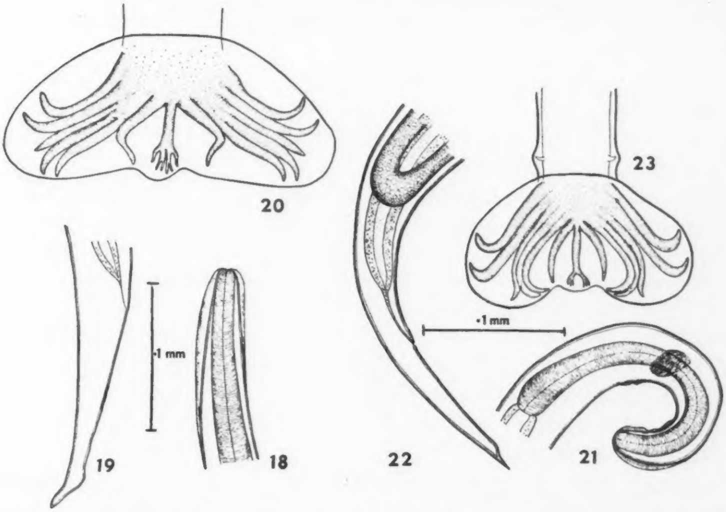
The female genitalia is double and the ovejectors are opposed, although the vulva is situated near the posterior end of the body, 1 mm. from the tail. There are 10 to 14 eggs in each uterus.

The tail is elongated and the anus is 0.15 mm. from the tip (Fig. 19).

The male bursa (Fig. 20) is small with a crenated border and a small dorsal lobe. The dorsal ray bifurcates towards its tip, each branch re-dividing and the medial sub-branches being again divided. The externo-dorsal ray runs parallel with the lateral rays for half its length, when it suddenly turns towards the dorsal. All the other rays are sub-equal and parallel for most of their lengths, diverging only slightly at the tips; the externo-lateral alone does not reach the margin of the bursa.

The spicules are equal, about 0.4 mm. long and bifurcate at the ends, one bifurcation being blunt and the other sharp.

This species agrees well with Lent and Freitas' account of *Graphidiops costalimai* from the Brazilian Tamandua. It would seem that the female of their "*Graphidiops* sp. I." is actually the female of this species.



FIGS. 18–20. *Graphidiops costalimai.* FIG. 18. *Head.* FIG. 19. *Tail of female.* FIG. 20. *Male bursa.* FIGS. 21–23. *Delicata pseudoappendiculata* sp. nov. FIG. 21. *Head.* FIG. 22. *Tail of female.* FIG. 23. *Male bursa.*

Delicata pseudoappendiculata sp. nov.

This species is also very common in the Tamandua. It is quite small, the female measuring 3.4 mm. and the male, 2.8 mm.

The body is transversely striated and usually forms two loose spirals in its anterior portion. In addition, the head is always bent ventrally and the cuticle on its anterior portion is swollen, giving it a somewhat asymmetrical appearance (Fig. 21).

The oesophagus is 0.23 mm. long. The nerve ring is about its middle and the excretory pore, which is conspicuous, behind this.

The ovarian tubules in the female both originate in the anterior part of the body and are almost without convolutions. The ovejectors and uteri are opposed, however, and situated in the posterior part of the body, the vulva being 0.5 mm. from the tip of the tail. The anterior uterus has 4 to 5 eggs, the posterior one only 2 to 3. The ovejectors are of the *Trichostrongylus* type.

The tail is gently tapered, suddenly narrowing at its tip to a fine dorsal spine. The anus is 0.1 mm. from the tip (Fig. 22).

The bursa of the male (Fig. 23) is relatively small with a small dorsal lobe and an accessory membrane. Small pre-bursal papillae are present. The dorsal ray is slender and Y-shaped, each part being divided into three processes. The externo-dorsal and the lateral rays are slender. The lateral rays are parallel to each other but the tip of the externo-lateral is bent ventrally, whereas the other two bend dorsally. The ventral rays lie close together

with their tips bent ventrally. They are more massive than the other rays and the ventro-ventral appears to be split.

The genital cone has two small papillae. An accessory piece, about half the length of the spicules, is present. The spicules are short stout rods, 0.1 mm. long. They are split at their ends and the inner face of the medial arms is provided with teeth.

This species appears to belong to the genus *Delicata*, being very closely related to the species *D. appendiculata* described by Travassos in 1928 from the Tamandua from Brazil. It differs from this species in the smaller size of the female, and in the ventral flexure of the head. No vulva flap was seen, although the lips are prominent. The spicules appear to have only two points, but the characteristic teeth noted by Travassos in *D. appendiculata* are present.

It differs from *D. khalili*, the second species found in this host by Travassos in Brazil, by its general smaller size, the shape of the spicules, the partial separation of the ventral rays. It resembles it more closely, however, in the shape of the female tail.

The name *Delicata pseudoappendiculata* sp. nov. is accordingly proposed for it.

Fontesia fontesi Travassos, 1928.

This is a common species in the Tamandua. It is easily recognized by its slender size and its asymmetrical head with the ventral prolongation to the mouth (Fig. 24). There is a slight pseudo-swelling at the head end caused by a constriction of the body but not of the cuticle. The tail of the female is conspicuously striated and ends in a very fine elongated point (Fig. 25). Two swellings are found on the ventral side of the body at the base of this extension. The male bursa is comparatively large with long, slender rays (Fig. 26). The two spicules are short and ornate.

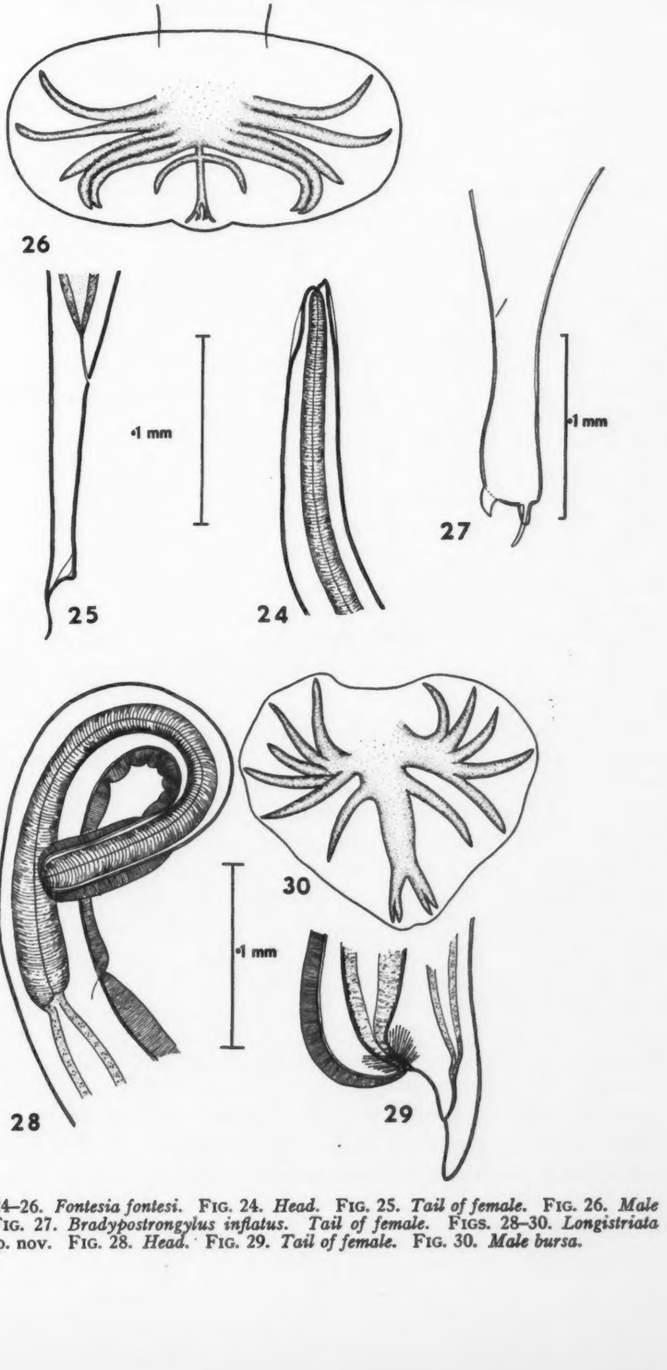
The Trinidad specimens do not differ in any significant points from those described by Travassos from the same host in Brazil.

Bradypostrongylus inflatus (Molin, 1861) Travassos, 1937

A single female specimen of this species was found in a Tamandua. It was 10 mm. long, with transverse striations throughout the entire length of the body; lateral alae occur in the medial region only. The oesophagus is 0.75 mm. long and there are large backwardly-directed cephalic papillae. The vulva, which is situated 2.0 mm. from the posterior end of the body, is a transverse slit, guarded by a backwardly directed flap. The uteri are divergent and the genital tubes, as in *Haemonchus*, spiral around the intestine.

The anus is 0.1 mm. from the blunt tail (Fig. 27). The tail itself carries three processes, a slender dorsal and two conical, more massive, projections; these arise from a flat base.

This species has been previously described by Travassos from this host from Brazil.



FIGS. 24–26. *Fontesia fontesi.* FIG. 24. *Head.* FIG. 25. *Tail of female.* FIG. 26. *Male bursa.* FIG. 27. *Bradypostrongylus inflatus. Tail of female.* FIGS. 28–30. *Longistriata cristata* sp. nov. FIG. 28. *Head.* FIG. 29. *Tail of female.* FIG. 30. *Male bursa.*

Longistriata cristata sp. nov.

This species from the stomach of the Tamandua is about 8 mm. long in the case of the female and 6 mm. in the male. The maximum width is 0.07 mm. The cuticle is finely striated and there is a conspicuous broad ventral crest, which is also striated and runs from head to tail. The cuticle around the head end is inflated and striated. The mouth is simple (Fig. 28). The oesophagus, which is only slightly swollen posteriorly, is 0.33 mm. long.

The genital system in the female is single and the vulva is situated just in front of the anus at the posterior end of the body. This is abruptly truncated, the actual tail being short and blunt (Fig. 29). The eggs are 65μ by 40μ and there are 40 to 50 in the uterus, in a single row, lying obliquely across it.

The male bursa (Fig. 30) is complete and triangular with no dorsal lobe, but a small dorsal notch is present. The main dorsal stem is massive and bifurcated only at the end; each bifurcation ends in two large digitations. The externo-dorsal rays are relatively small and arise from near the base of this stem. The other rays are spread out fan-wise and are about equal in size.

The spicules are 0.5 mm. long and slender, but each ends in a finger-like process. There were neither accessory piece nor prebursal papillae present but just in front of the bursa is a small secondary crest, which is quite short, in addition to the main ventral crest which is continued to the head.

This species seems to belong to the genus *Longistriata*, and to the sub-genus *Longistriata*, but it differs from the described forms in the triangular bursa and the massive dorsal ray. It is accordingly regarded as a new species with the name *Longistriata cristata* sp. nov.

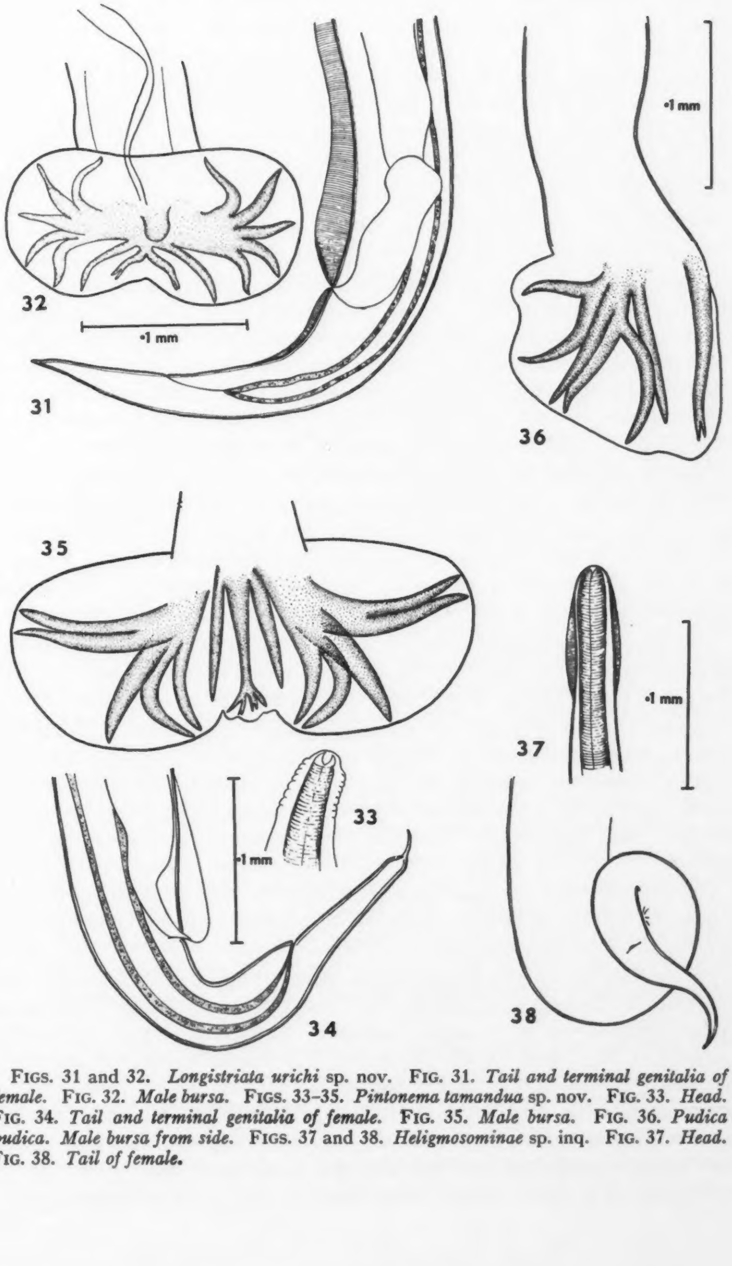
Longistriata urichi sp. nov.

These nematodes from the Tamandua were coiled in a loose spiral and consequently their length was difficult to determine; one typical female, however, measured 2.5 mm. long with an oesophagus measuring 0.32 mm. The head is simple and slightly swollen; the mouth is a simple pore. Lateral crests are present and towards the tail of the female, a ventral crest also.

The female genitalia is single and opens to the exterior about 0.22 mm. from the tip of the tail (Fig. 31). A massive ovejector is present. The eggs measure about 60μ by 40μ. The anus is 0.09 mm. from the tip of the sharp, acute tail.

The male bursa is small, without a dorsal lobe, the dorsal ray being split almost to its base (Fig. 32). All the rays are spread out so that their apices are about equidistant from each other. The dorsal rays end in two small digitations; all the others are slender and pointed. The ventro-ventral rays are curved inwards. There is no accessory piece and the spicules are slender, needle-like, poorly chitinized structures, measuring 0.15 mm. each.

This very large genus has recently been revised by Travassos (1937) and he has recognized several sub-genera. This species belongs to the sub-genus *Carolinensis*, characterized by the long spicules and the externo-dorsal ray rising independently of the dorsal. Only two species occur in this sub-genus,



FIGS. 31 and 32. *Longistriata urichi* sp. nov. FIG. 31. *Tail and terminal genitalia of female.* FIG. 32. *Male bursa.* FIGS. 33–35. *Pintonema tamandua* sp. nov. FIG. 33. *Head.* FIG. 34. *Tail and terminal genitalia of female.* FIG. 35. *Male bursa.* FIG. 36. *Pudica pudica. Male bursa from side.* FIGS. 37 and 38. *Heligmosominae* sp. inq. FIG. 37. *Head.* FIG. 38. *Tail of female.*

viz., *carolinensis* and *musculi*, both described by Dikmans (1935) from rodents in the United States. The first species (from deer mice or prairie meadow mice) is rather larger, possesses longer spicules and an accessory piece in the male and has a shorter blunter tail. The second species (from *Mus musculus*) is similarly larger, with longer spicules, the dorsal ray split only a third of its length in the male, and a shorter tail in the female. The present species is accordingly regarded as undescribed and the name *Longistriata urichi* sp. nov. is proposed for it.

Pintonema tamandua sp. nov.

A number of specimens of this species was found in Tamandua.

The female is 3.8 mm. long and the male only slightly smaller. Both are about 0.1 mm. thick. The body is of a uniform width and nearly cylindrical except at the ends. The anterior end tapers rapidly and is square cut. Behind the oesophagus, the body is coiled in one or two coils. The entire body is striated transversely but it has also a number of longitudinal ridges. The cuticle at the head end is swollen and more coarsely striated.

There is a prominent mouth cavity (Fig. 33) and a relatively short oesophagus (0.32 mm.) with a slight posterior enlargement.

The female genitalia is single. The uterus contains 8 to 10 ova, 60μ by 40μ in size. The ovejector is short but voluminous with a sudden narrow constriction joining it to the ovary. The vulva is situated 0.2 mm. from the tip of the tail; it is a transverse slit, anterior to which is a ventral cuticular expansion, which is without striations (Fig. 34).

The tail of the female is always bent ventrally at a point between the vulva and the anus. The anus is about 0.1 mm. from the tip of the tail. The tip of the tail narrows to form a small filariform appendix.

The male bursa (Fig. 35) is large with a small dorsal lobe. The margin is crenate. The dorsal ray is slender and bifurcates near its tip, each bifurcation dividing almost immediately into two further divisions; the median division is split again. The ventral and the lateral groups are each compact and separate from each other. The ventral rays are long, slender, and close together.

The genital cone has two prominent papillae. The spicules are long and slender, 0.29 mm. in length, with the tips slightly swollen and apparently bifurcated. A small gubernaculum is present.

This species appears to belong to the genus *Pintonema* created in 1935 by Travassos to include four species from *Dasypus novemcinctus*. The present species differs from all of these, however. It is larger than all except *P. pulchra*, which it most closely resembles; the female of this species has not yet been observed and so no comparison is possible. The prominent mouth cavity is not described for it, however, prebursal papillae are absent, the terminal digitations of the dorsal ray are S-shaped, and the externo-dorsal rays widely spread out; the spicules also are less slender and not swollen terminally. For these reasons, therefore, this species is regarded as new and

the name *Pintonema tamandua* sp. nov. is proposed for it. No species of *Pintonema* were found in the armadillo from Trinidad.

Pudica pudica (Travassos, 1921) Travassos & Darriba, 1929

A few examples of this species, hitherto recorded only from rodents, were found in a Tamandua.

The head end is sharply constricted from the rest of the body and is conspicuously striated transversely. The mouth is simple.

There are about ten longitudinal ridges on the body, each ridge carrying the fine transverse striations of the body.

The oesophagus is 1.5 mm. long.

The female is 2.5 mm. and the male 2.25 mm. long. The tail of the female is short and stumpy. The genital system is single and opens posteriorly just in advance of the rectum. The single uterus is long and contains a dozen or so eggs. These are thin-shelled and measure about 60μ by 40μ.

The male bursa is relatively voluminous (Fig. 36). The main dorsal stem is split for about two-thirds of its length to form two long dorsal rays; each ends in a bifurcation. The externo-dorsal ray is widely separated from the dorsal and lies close to the dorso-lateral. This, in turn, is widely separated from the other two lateral rays, which lie close together. The ventral rays are widely separated from each other.

There is no accessory piece. The spicules are 0.23 mm. long and each ends in a pair of simple points.

This parasite was originally described by Travassos (1921) from *Dasyprocta agouti* from Brazil under the name of *Viannaia pudica*. As this host also occurs in Trinidad, it is probable that the Tamandua is an abnormal host, a circumstance which would account for the small number collected. In spite of this fact, there are no significant differences to note from Travassos' original description.

HELIGMOSOMINAE sp. inq.

A single female heligmosome was found in the Pigmy Anteater (Figs. 37 and 38). It was a small specimen, 4 mm. long, with the body covered throughout with very fine striations. The head is simple, with a cuticular enlargement more coarsely striated than the remainder of the body. The mouth is simple and the oesophagus slender and 0.3 mm. long. The excretory pore, at the base of the oesophagus, is guarded by two small lips. The genital system is simple and the vulva is 0.1 mm. in front of the anus, which in turn is about the same distance from the tip. The tail is elongated and tapers to a fine point.

As no trichostrongyles have been yet recorded from this host and as no males were available, it cannot be referred to any species. It belongs, however, to the subfamily Heligmosominae and as such it is placed on record.

TRICHOSTRONGYLIDAE sp. inq.

A single female was found in an armadillo but was in such a poor condition that further identification was impossible.

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CANADIAN JOURNAL OF RESEARCH

VOLUME 17
1939
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Published by the
NATIONAL
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Errata

Page 17, footnote 1, add "Manuscript received October 7, 1938."

Page 211, third line, for "*Gyraulus*" read "*Galba*."